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JPRS Report

Science & Technology

Japan

Industrial Science and Technology Frontier Program (ISTF)

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Industrial Science and Technology Frontier Program (ISTF)

43070034A Tokyo AGENCY OF INDUSTRIAL SCIENCE AND TECHNOLOGY, MITI in English 1993 pp 2-40

[Text]

I. Outline of the Program

1. Purpose and Necessity

The Agency of Industrial Science and Technology has been implementing the three national R&D programs in the area of industrial science and technology. The National R&D Program (Large-scale Project) has mainly carried out the research and development on large scale system and plants since 1966. R&D Project of Basic Technologies for Future Industries has executed relatively basic research and development mainly on component technology such as material and bio-technology since 1981. National R&D Programs for Medical and Welfare Apparatus has made research and development toward the realization of a true welfare society since 1976. These programs, until now, have attained many useful results and achieved the great technology progress under the collaboration between industry, university, and government using governmental funds.

Today, the atmosphere surrounding the current programs have changed in term of increasing interaction between basic science and technology, and demands for more fundamental and creative R&D, the pursuit of higher quality of life (QOL) and more emphasis on international aspect in implementing R&D have occurred.

In this context, MITI restructed the three programs into a new integrated Program named Industrial Science and Technology Frontier Program (ISTF) to cope with the changing environment in FY 1993 starting April.

2. Content of Program

This program focuses on the following R&D areas of the industrial science and technology.

(1) The fundamental and creative R&D which will contribute to a further development of the economy and society.

—to build a new technology paradigm with a new concept, philosophy and approach.

—to make technological breakthrough.

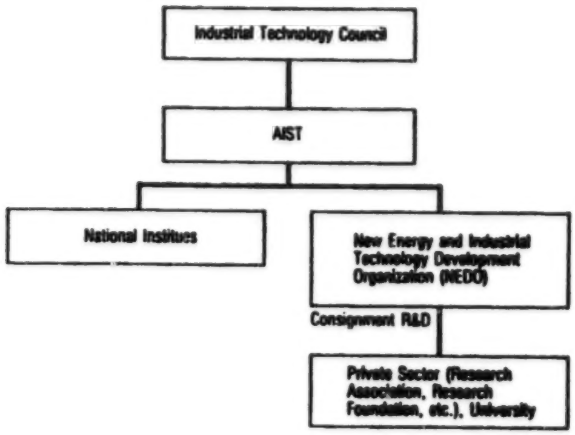
(2) The mission oriented R&D to attain the social goal.

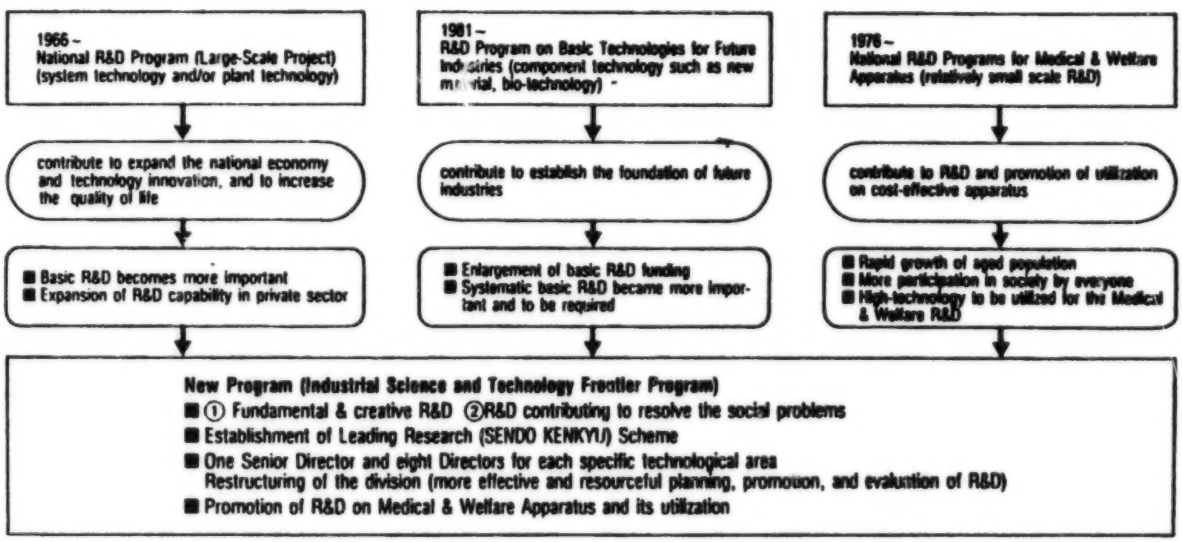
—to meet the public demand and QOL.

—to secure stable supply of the natural resources.

—to construct the basis for promotion of science and technology.

In this program, pre-project study including the evaluation of possibility to start the project style R&D will be carried out under the Leading Research (SENDO KENKYU) scheme. This scheme will cope with the R&D subjects which are difficult to undertake as project immediately for some reason such as technological uncertainty, though the possibilities of promoting such projects in the future can not be rejected.


Industrial Technology Council
AIST
National Institutes
New Energy and Industrial Technology Development Organization (NEDO)
Consignment R&D
Private Sector (Research Association, Research Foundation, etc.), University


1966~
National R&D Program (Large-Scale Project)
(system technology and/or plant technology)
contribute to expand the national economy and technology innovation, and to increase the quality of life
■ Basic R&D becomes more important
■ Expansion of R&D capability in private sector
1981~
R&D Program on Basic Technologies for Future Industries (component technology such as new material, bio-technology)
contribute to establish the foundation of future industries
■ Enlargement of basic R&D funding
■ Systematic basic R&D became more important and to be required
1976~
National R&D Programs for Medical & Welfare Apparatus (relatively small scale R&D)
contribute to R&D and promotion of utilization on cost-effective apparatus
■ Rapid growth of aged population
■ More participation in society by everyone
■ High-technology to be utilized for the Medical & Welfare R&D
New Program (Industrial Science and Technology Frontier Program)
■ ① Fundamental & creative R&D ②R&D contributing to resolve the social problems
■ Establishment of Leading Research (SENDO KENKYU) Scheme
■ One Senior Director and eight Directors for each specific technological area
Restructuring of the division (more effective and resourceful planning, promotion, and evaluation of R&D)
■ Promotion of R&D on Medical & Welfare Apparatus and its utilization

3. R&D Scheme

This program is implemented under the collaboration between industry (private sector), academic association (universities, etc.), and government (national institutes).

R&D in this program are managed by directors allocated to each R&D area.

R&D of ISTF Projects Schedule and Budgets

Unit: one hundred million yen

	Period (FY)	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Superconductivity																											
Superconducting Materials and Devices	1988 ~ 1997													11	19	(23)	28	29	32	○							
New Materials																											
High-performance Materials for Severe Environments	1989 ~ 1996														3	10	17	(17)	18								
Non-linear Photonics Materials	1989 ~ 1998														2	5	5	(5)	6		○						
Advanced Chemical Processing Technology	1990 ~ 1996															8.3	12	17	(19)								
Silicon-based Polymers	1991 ~ 2000																0.4	4	6		○		○				
Biotechnology																											
Marine Biotechnology (Fine Chemicals from Marine Organisms)	1988 ~ 1996													0.2	3	12	14	14	(14)								
Molecular Assemblies for a Functional Protein System	1989 ~ 1998														2	3	5	(5)	6		○						
Production and Utilization Technology of Complex Carbohydrates	1991 ~ 2000																0.5	3	4	○			○				
Electronics, Information and Communication																											
Bio-Electronic Devices	1986 ~ 1995											1	1	2	3	(3)	3	3	3								
New Models for Software Architecture	1990 ~ 1997															0.5	3	(3)	3		○						
Quantum Functional Devices	1991 ~ 2000																0.4	5	7	○			○				
Ultimate Manipulation of Atoms or Molecules	1992 ~ 2001																	0.3	5				○				
Machinery and Aerospaces																											
Advanced Material-Processing and Machining System	1986 ~ 1993											0.2	11	17	23	(29)	32	26	17								
Super/hyper sonic Transport Propulsion System	1989 ~ 1998														0.3	16	30	(39)	41								
Micromachine Technology	1991 ~ 2000																0.3	9	15		○						
Natural Resources																											
Manganese Nodule Mining System	1981 ~ 1996						0.5	9	12	14	(11)	10	8	10	11	10	8	9	11								
Human, Life and Society																											
Underground Space Development Technology	1989 ~ 1995														0.3	8	13	(14)	14								
Human Sensory Measurement Application Technology	1990 ~ 1998															0.5	17	20	21	○							
Medical and Welfare	1976 ~	3	8	8	8	9	9	8	8	7	7	7	7	7	7	7	7	7	9								

( ) The FY of interim evaluation ○ The FY of final evaluation

National Research and Development Program	139	137	139	148	167	198	153	160	117	117	132	151	136	129	111	113	117									
Research and Development Program on Basic Technologies for Future Industries						27	18	58	60	61	65	60	61	68	75	79	82									
National Research and Development Programs for Medical and Welfare Apparatus	3	8	8	8	9	9	8	8	7	7	7	7	7	7	7	7	7									
Industrial Science and Technology Frontier Program																		253								

II. On-Going Theme

Superconductivity

Since the first high-temperature oxide superconductor was discovered in 1986, a variety of superconducting materials with critical temperatures, Tc's, higher than the liquid nitrogen temperature (77K) have been found one after another. These discoveries have had strong impacts on various industrial fields such as transportation, electric power and electronics, etc., and the high temperature superconductors are expected to make significant contributions to the progress of human society. However, for industrial applications, it is necessary to improve properties such as the critical current density, Jc, the critical magnetic field, Hc, as well as Tc.

Superconducting Materials (1988-1997)

Purposes of Research and Development

New high-Tc superconducting materials are being sought and fundamental process technologies to obtain high performance materials are being developed for industrial applications.

Contents of Research and Development

(1) Search for new high-Tc materials

New high-Tc superconducting materials, derived from the infinite layer structure, are synthesized by using ultra-high pressure techniques. The existing non-superconductive materials are transformed into high-Tc superconductors by using a variety of solid-state chemistry techniques.

(2) Development of fundamental process technologies

Melt-solidification methods, including the single-crystal pulling method (SRL-CP method), the modified MPMG method, as well as the metal-organic deposition method, are newly developed in order to attain high-Jc and high-Hc superconductors. Deposition and micro-fabrication techniques of high-Tc superconducting thin films are also developed for future electronics applications.

(3) Development of characterization techniques

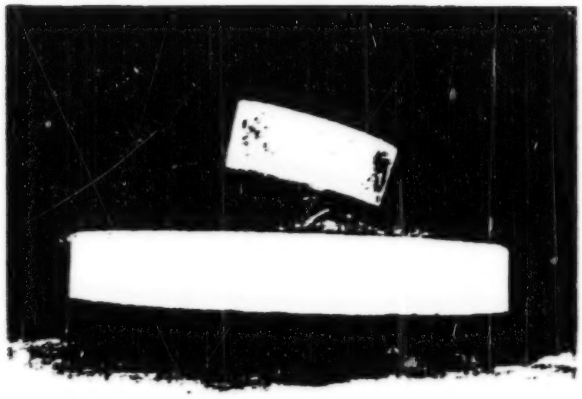
Microscopic crystalline structures, accurate chemical compositions and electromagnetic properties of high-Tc superconductors are characterized under extreme conditions, such as at low temperatures and under ultra-high vacuum conditions.

(Unit: million yen)

Field	Theme Name	Period (FY)	Budget for FY 1993	Outline of Theme	R&D Results
Superconductivity	Superconducting Materials and Devices	1988 ~ 1997	3,226	Development of new superconducting materials, processing technologies for applying superconducting materials to electric power equipment, e.g. magnets and wires, and technologies for fabricating superconducting electronic devices.	The highest critical temperature (Tc = 127K) in the world was obtained. A strongly pinned superconductor MPMG was also developed. Large single crystals (5 × 5 mm) of Y-based materials have been successfully grown for the first time. The proximity effect and Josephson current were confirmed. A three-terminal device with BKBO superconductor has been developed and the preliminary operation was confirmed.
New Materials	High-performance Materials for Severe Environments	1989 ~ 1996	1,766	Development of carbon/carbon composites, intermetallic compounds, and fiber reinforced intermetallic compounds which can be used to develop a space plane and SST/HST.	Sic fiber, modified by the electron beam method, was developed to withstand high temperatures (~ 1500°C).
	Non-Linear Photonics Materials	1989 ~ 1998	590	Development of photonic materials which exhibit high nonlinear optical susceptibilities and high speed response times for application of optical communication systems.	Well-designed conjugated polymers and semiconductor dispersed in glassy materials showed the highest susceptibility.
	Advanced Chemical Processing Technology	1990 ~ 1996	1,850	R&D on the advanced synthetic processes for functional materials by means of (1) ultra-high purification of metals, (2) deposition and sintering of ultra fine particles (3) structure control of organic molecules, and (4) in-situ measurement techniques.	Ten-fold increase in the purity of some noble metals was accomplished by laser-induced processes. Inorganic ultra-fine particles were obtained by using various plasmas. The application of magnetic field to electrode reaction, and laser ablation was found to be useful for the preparation of organic materials.
	Silicon-Based Polymers	1991 ~ 2000	568	Research on technologies for the molecular design and synthesis of silicon-based compounds, and development of properties such as high heat-resistance, strength and superior electrical characteristics.	New synthetic routes for silicon-based polymers such as ring opening polymerization of silacyclo-compounds, catalytic dehydration of hydropolysilanes, insertion of acetylene analogue into polysilane skeleton, plasma polymerization etc. as well as functionalization of known polysilanes have been investigated extensively.
Biotechnology	Marine Biotechnology (Fine Chemicals from Marine Organism)	1988 ~ 1996	1433	The goal of this project is to search and elucidate biological phenomina of marine organisms and to develop basic technolgoies for the utilization of various marine bio-resources.	In order to apply biotechnology, which have been developed for terrestrial organisms, to marine organisms, basic researches were carried out on sampling, cultivation, maintenance, and breeding of marine organisms. Also, useful fine chemicals were screened from marine organism.
	Molecular Assemblies for a Functional Protein System	1989 ~ 1998	557	Basic technologies for artificial reconstitution of functional protein assemblies are to be developed. In industrial applications, the technology would make it possible to artificially reconstitute the complex functions of the functional protein assemblies of living bodies.	Proteins suitable for artificial reconstitution were screened from functional protein assemblies in biomembrane, and basic conditions for analyzing their function and structure were established. The elementary technologies necessary for artificial reconstitution of functional protein assemblies were established.
	Production and Utilization Technology of Complex Carbohydrates	1991 ~ 2000	438	The project aims to establish basic technologies for using complex carbohydrates industrially which are basic substances in organisms and have important functions such as substance recognition.	Basic researches on chemical and enzymatic synthesis of complex carbohydrates, on production of complex carbohydrates by animal cells and yeast cells, and on remodelling and structure analysis, were carried out.
Electronics, Information and Communication	Bio-Electronic Devices	1986 ~ 1995	291	Development of bio-electronic devices for future computer elements by using biological information processing functions based on plasticity, molecular recognition and self organization at a cell level.	Neural activity patterns of the brain were studied using an optical recording system, and a visual cortex model was developed. Elemental functions (e.g. self-organization and plasticity) of artificial organic membranes were evaluated.
	New Models for Software Architecture	1990 ~ 1997	306	Development of innovative models for flexible software architecture so that software can function according to the surrounding situation.	Key components for computational model for cooperation in the area of situational reasoning, self reorganization and semantic adaptation are identified.
	Quantum Functional Devices	1991 ~ 2000	721	Development of control technology of new devices functions based on such quantum effects as wave properties for the purpose of developing ultra-high speed, multi-function electronic devices.	Qunatum phenomena in semiconductors were surveyed for device application. Development of microfabrication techniques for quantum structures and fabrication technology for element devices has been started.
	Ultimate Manipulation of Atoms or Molecules	1992 ~ 2001	501	R&D on technology for precise observation and manipulation of atoms or molecules on solid surfaces or in space and its supporting technology.	
Machinery and Aerospace	Advanced Material-Processing and Machining System	1986 ~ 1993	1,670	R&D on high-power excimer laser technology, high density ion beam technology and ultra-precision machining equipments in order to enable the ultra precison and fine processing, and ultra-high quality surface layer modifiction etc. which were impossible to be achieved by conventional processing technologies.	Equipments which would achieve the final targets of this project for high power, high repetition and long-life excimer laser technologies, large current and high energy ion beam technologies, and ultra precision machining technology for highly efficient and accurate processing are developed, and overall test is proceeded.

Field	Theme Name	Period (FY)	Budget for FY 1993	Outline of Theme	R&D Results
Machinery and Aerospace	Super/hyper-sonic Transport Propulsion System	1989 – 1998	4,053	Research and development workm on the technologies required for the super/hypersonic propulsion system to achieve the flight from outline of these subsonic speed to approximately Mach 5 with high reliability and economical operation.	Research and development work on ramjet and turbojet components R&D Results were carried out. Based on these results, the preliminary design of the prototypes of the propulsion system has been started.
	Micromachine Technology	1991 – 2000	1,503	This project is designed to undertake R&D on the establishment of the technological framework to realize a micromachine composed of microscopic functional elements, capable of moving in complex devices like power plants and in narrow parts of living bodies and performing a particular work on its own.	Conceptual designs about micromachine system for power plants and medical use were finished, and microscopic functional elements necessary for them, such as sensors and actuators were developed and basic phenomena were confirmed.
Natural Resources	Manganese Nodule Mining System	1981 – 1996	1,060	R&D on the system technology intended for safe and efficient mining of the manganese nodules that contain important nonferrous metals, such as nickel, copper, cobalt, and exist in deep seabeds in large quantities.	Detailed design has almost been completed following completion of element technology development and basic design. Current R&D relates to the manufacturing of ocean testing equipment and to ocean test planning.
Human, Life and Society	Underground Space Development Technology	1989 – 1995	1,422	The researches are performed to establish the underground space development technology in order to utilize underground spaces at depths of greater than 50m below ground level, as the third frontier following to the space and ocean. Concretely, geological survey and evaluation technologies, dome construction technologies, environment conditioning and hazard prevention technologies are researched.	Conceptual design was done and fundamental techniques were developed in regard to geological survey and evaluation technologies, dome construction technologies, and technologies of environment conditioning and hazard prevention.
	Human Sensory Measurement Application Technology	1990 – 1998	2,067	In orer to improve daily-life products, working and living environments so that they reflect sensory evaluation of human being, research and development have been carried out on technology of easy and quantitative measurement of various human characteristics.	R&D have been carried out partly in such areas as measurement technology of physiological effects, simulated environment presentation technology, development of an evaluation simulator and techniques for correlations among environmental stimuli, physiological effects and magnitude of sensation.
Medical and Welfare	Non-Invasive Continuous Blood Glucose Monitoring System	1990 – 1993	72	System to determine blood glucose level by measuring suction effusion fluid with an ISFET biosensor.	Detailed design was completed on a suction effusion fluid sampler, a material preparation element, a sensor and a data processor. Using these components the first prototype device was manufactured and evaluated.
	Optical Tomographic Imaging System	1992 – 1998	96	Diagnostic system which can obtain tomographic images of oxygen metabolism in living bodies by the CT (Computed Tomography) method using nearinfrared light.	Conceptual design was completed on a light source, a light detector, a light conductor, a scanner and analysis algorithm.
	Stereotactic Treatment System for Cancer	1992 – 1996	101	A treatment system for cancer, in which effective treatment is made successfully by applying high dose of X-ray irradiation to a lesion with almost no injury to normal tissue surrounding the lesion anywhere in the whole body.	Conceptual design was completed on treatment couch and a total system.
	Digital Hearing Aids	1990 – 1994	112	A hearing aid with improved speech intelligibility and comforting sound realized by digital signal processing.	The second stage of design and manufacturing was completed on an adjusting the device, a method of evaluating the hearing aid. At the same time, a clinical evaluation was initiated for the first stage device that has been assembled as a total system.
	Ambulatory Apparatus with Weight Bearing Control	1991 – 1995	103	An apparatus which controls the length of the leg-support, and assists the handicapped with a gait disturbance.	The first stage design and manufacturing was completed on a mechanism of supporting the pelvis and torso, a program for controlling the system, a variable length supporting mechnism, a power mechanism and a total system. A preliminary experiment was also conducted.
	Next-generation Oral Device Engineering System.	1993 – 1997	41	A total system for designing and producing high fit and low cost oral devices such as artificial teeth and teeth roots. The system consists of a three dimensional teeth shape measuring apparatus, a device design supporting system and an automatic precise manufacturing machine.	Not yet initiated.
	Evacuation Care System	1989 – 1993	75	System to remove the solidified feces stagnating in the rectum by suction with crushing and softening by an ultrasonic system.	Evacuation and improvement was carried out on an ultrasonic oscillating and vibrating unit, a crushing insert device, an irrigation fluid supplyer, a storage-waste treating system and a safety system. Furthermore, this device was applied to solidified faces of an experimental animal and it was verified that the feces was smoothly crushed and removed and no bad effect to the tissue was observed.
	Therapeutic Training System for Preventing the Incontinence of Urine	1991 – 1994	86	Therapeutic training system for preventing the incontinence of urine by measuring methods of the urine without directly contacting internal organs and using bio-feedback system etc.	The first stage design, manufacturing and evaluation was carried out on a urine volume measuring system using impedance and ultrasonic methods, a urination controlling system using electric stimulation and iontophoresis methods and a biofeedback system. Furthermore the first stage design and manufacturing of the total system was completed.

Field	Theme Name	Period (FY)	Budget for FY 1993	Outline of Theme	R&D Results
	System for Supporting Independent Evacuation	1993 – 1998	20	System for supporting independent evacuation by using a bed-side portable toilet with a warm water washer, a preservation freezer of feces, a strong odor absorber and an easy processing function as well as a lifter that supports the transfer from the bed to the toilet.	Not yet initiated.
Medical and Welfare	Three-dimensional Information Display Unit for the Blind	1989 – 1993	69	An information display unit using vertically moving pins to present three-dimensional information.	Experiment on tactile sensation in response to the presentation of three-dimensional objects was performed with a model of pin display. Ultra-small actuator was manufactured and it successfully performed a linear movement. A circuit with one-chip microcomputer was manufactured to control the actuator unit. A control method was verified for the pin display device consisting of the actuator units.
	Comprehensive System for Supporting Wheelchairs	1993 – 1998	32	Development of a design and manufacturing system to improve the adaptability of wheelchairs to the users and of a low-cost and small-size transportation support system used in public space.	Not yet initiated.
	Survey on an international R&D cooperation in the field of medical and welfare apparatus	1992 –	19	Preliminary survey to conduct an international R&D cooperation in the field of medical and welfare apparatus that accurately fits the domestic and overseas needs concerning preventive diagnostic and treatment devices for incurable diseases including cancer, circulatory disorder and AIDS as well as other devices such as artificial organs and sensory substitutes.	Possible R&D theme was surveyed that should be conducted under international cooperation.
	Fundamental Research on Welfare Apparatus Technologies	1993 –	60	Multidisciplinary and fundamental studies on welfare apparatus technologies that relates to a variety of research fields.	Not yet initiated.
	Project for the collection, analysis and distribution of information on welfare apparatus	1993 –	52	① Survey for technological realization • Excavation and matching of technological seeds that realize needs of users as apparatus. ② Construction of a data base • Construction of a data base concerning the characteristics of the elderly and the handicapped which provide basic information for the R&D of welfare apparatus.	
	Project for promoting the development of practical welfare apparatus	1993 –	106	A project for financially support the development of welfare apparatus that is based on a new technology developed with the national R&D programs for medical and welfare apparatus as well as an independent R&D by national research laboratories and enterprises.	
Leading Research	Inorganic Fusion Materials with Higher Order Structure	1993 –	51	Basic research on technologies for controlling the microstructure of inorganic materials at all structural levels (from atomic to macro levels), which are necessary for the development of the new inorganic materials with multi-functions.	
	Autonomous Reaction Materials	1993 –	49	Basic research on chemistry and physics of stimulus reacting polymers comprising exploration of those materials, fixation techniques and analysis of stimuli-structure-movement to clarify reaction mechanisms, being aimed at materialization of autonomous movement like creatures do in their lives.	
	Jungle Biotechnology (Technology for Preservation and Utilization of Function of Tropical Organism)	1993 –	52	The tropics possess an abundance of biological species with properties as yet unknown, constituting a potentially valuable resources for humankind. Basic research will be conducted with a view to protecting these diverse organisms and utilizing their biological functions.	
	Femtosecond Technology	1993 –	48	Basic technology for femtosecond (10^{-15} second) phenomena, such as generation and control techniques of femtosecond optical/electrical pulses, will be studied through the elucidation of physical phenomena in femtosecond time region.	
	Ecofactory	1993 –	48	To establish technologies for achieving harmony with the global ecological system through the establishment of Ecofactory (Ecology-Conscious Factory) technology, leading and basic research for the production system technology, restoration system technology and system technology are advanced.	

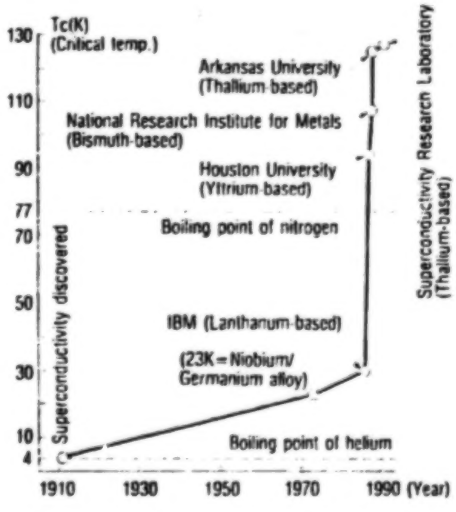


Magnetic levitation experiment using high-Tc superconducting material (top and bottom; High-Tc superconducting materials, middle; permanent magnet).

1. SUPERCONDUCTING PHENOMENON

The superconducting phenomenon takes place in certain types of material; when the temperature is gradually decreased, the electrical resistance suddenly becomes zero at a certain temperature (critical temperature). This phenomenon was discovered in 1911 with mercury by Dr. Kamerlingh Onnes, Leyden University in Holland. In 1986, an oxide based superconducting material was discovered which presents the superconducting phenomenon at a higher temperature than that in the conventional metal-based superconducting materials.

2. RISE IN CRITICAL TEMPERATURE OF MAJOR SUPERCONDUCTING MATERIALS



3. CHARACTERISTICS OF SUPERCONDUCTING MATERIALS

(1) Zero electrical resistance

Below the critical temperature, the superconducting materials lose their electrical resistance. Thus, electric currents, once they begin to flow, can continue forever.

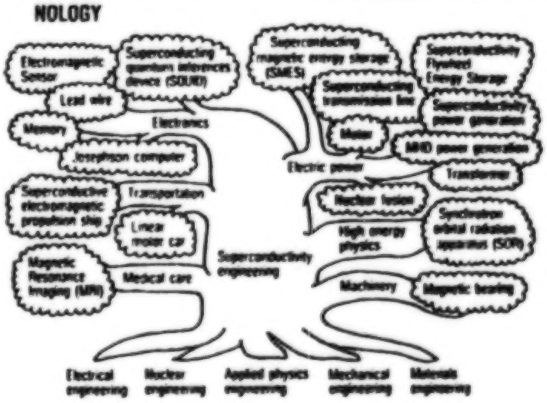
(2) Meissner effect

In ordinary materials, lines of magnetic force permeate the materials. Superconducting materials, however, repel lines of magnetic force at their critical temperature and below. This is referred to as Meissner effect.

(3) Josephson effect

When an extremely thin insulator is placed between superconducting materials, a special electric current (tunnel current) flows without applying voltage across the superconducting materials. This is referred to as the Josephson effect.

4. APPLICATION FIELDS OF THE SUPERCONDUCTIVITY TECHNOLOGY



Superconducting Devices (1989-1997)

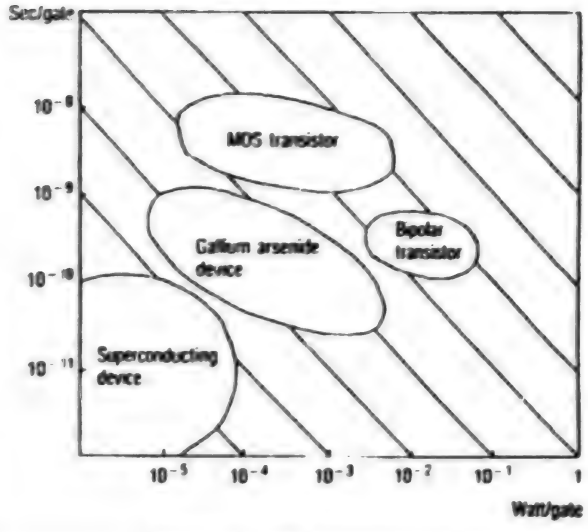
Purposes of Research and Development

By establishing basic technologies essential to develop electronic devices which use high-temperature superconducting materials, new devices with sophisticated functions can be developed.

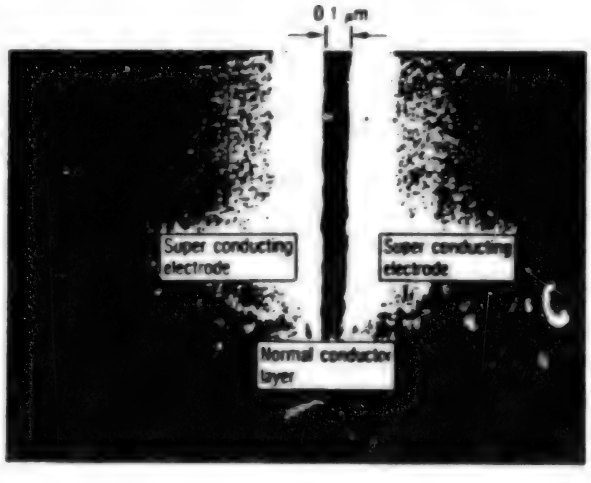
Contents of Research and Development

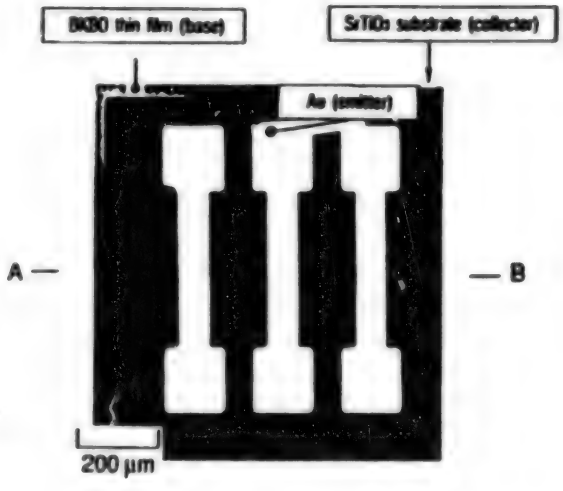
Superconducting devices are expected to enable high-speed switching circuits and to decrease power consumption with the possibility that their physical properties will open up a new application field of electronics. In the future, a new compact computer will be developed using superconducting devices of ultra-speed processing.

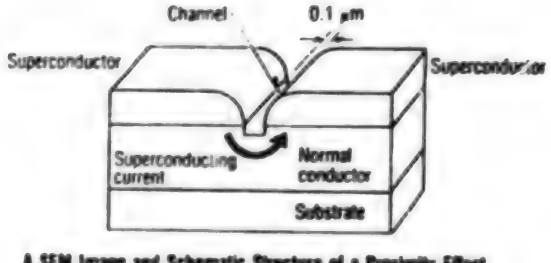
High-performance thin film forming process and microfabrication technology are being studied to establish basic technologies for superconducting devices. The final target is to develop the prototype superconducting devices and to confirm the basic operation.



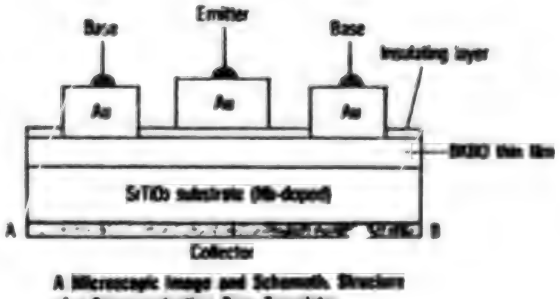
Prospective States of Superconducting Devices







A SEM Image and Schematic Structure of a Proximity Effect Transistor



A Microscopic Image and Schematic Structure of a Superconducting Base Transistor

New Materials

Study on new materials is focused on improvement of performance, say, electric, optical and gas separation properties of polymer, electronic and optic properties of ceramics, severe high temperature property and superconductivity of metal, and mechanical property of nano-composite.

The requirement for new materials depends on social needs. By analogy with the progress of today's society, it is expected that society in future is largely composed of elderly people and highly oriented to information. It is also expected that the technology for global environmental protection is required. Thus, it is necessary to develop materials with following performance: high strength at elevated temperature, light weight, resistance to corrosion, easy decomposition, photo reactivity, magnetic property, electric conductivity, bio-mimetic property, bio-compatibility, and etc.

High-Performance Materials for Severe Environments (1989-1996)

Purpose of Research and Development

There are various kinds of projects for following new technologies which are expected to come into practical use by early 21st century; aerospace technology such as, space plane, SST, HST, new energy technology such as, nuclear fusion, coal liquefaction for power generation, and etc. In R&D of these technologies, it is necessary to develop a structural material which has excellent properties, say, high specific strength and stiffness, superior resistance to heat shock, thermal fatigue and oxidation in severe environment.

Since a single material cannot provide all the superior performances described above, an appropriate material should be developed for each service condition. In this project, ordered intermetallic compounds, intermetallic matrix composite material, and carbon fiber/carbon-based matrix composite material are to be developed as the materials which have superior heat resistance and high specific strength at high temperature.

Contents of Research and Development

(1) Development of ordered intermetallic compounds

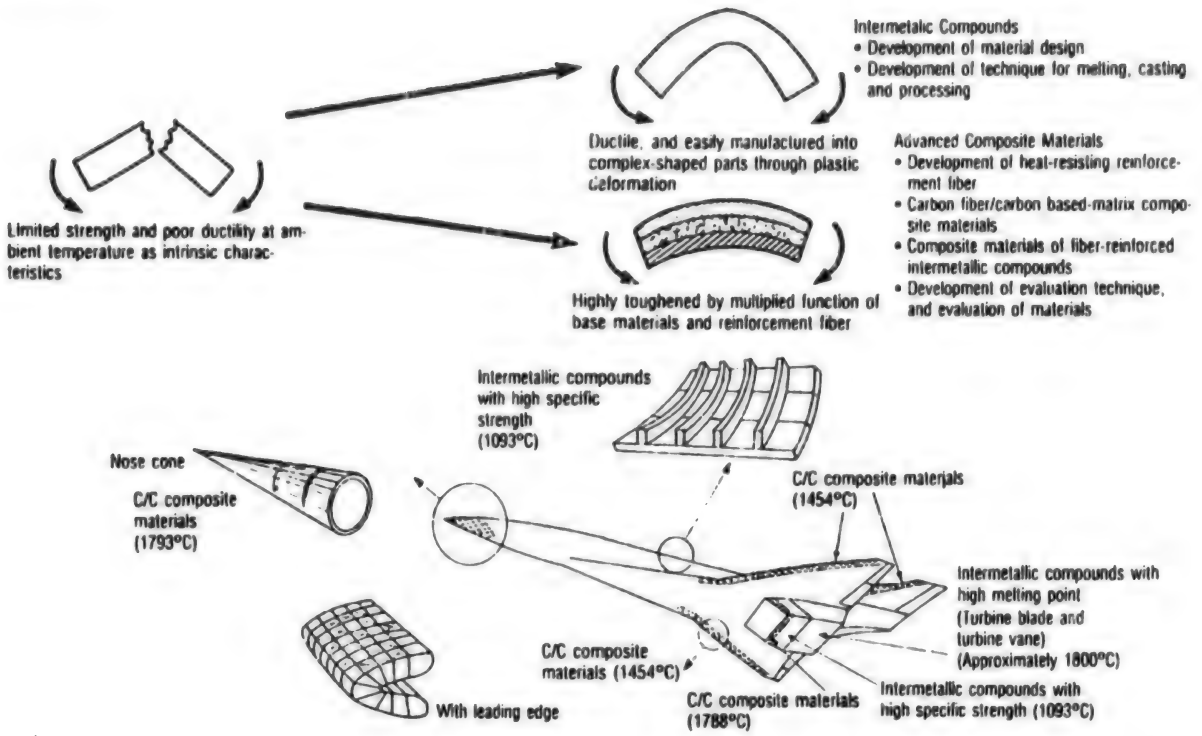
Material design and processing technology for high specific strength and high melting point intermetallic compounds are to be developed.

(2) Development of high-performance composite materials

Heat resistant reinforcement fibers are to be developed. Technique for composition and forming of carbon fiber/carbon-based matrix composite material, and that for fiber reinforced intermetallic compounds are also to be developed.

(3) Development of evaluation techniques and evaluation of materials

Thermal, mechanical and chemical properties at severe high temperature are to be evaluated.



Examples of the Application of Advanced Materials for Space Planes

Nonlinear Photonics Materials (1989-1998)

Purpose of Research and Development

Various information used in our society has increased today, then qualitative and quantitative rapid advance of the communication and data processing technology has been demanded. To communicate and deal with such a large amount of information, it is necessary to enlarge memory capacity and develop an ultra-fast data processing system. The present information system works through nonlinear operations of electric signals, such as amplification, logical operation, storing, switching, and so on. There is, however, a limit of operation speed using electric signals. A new advanced operation technology using optical devices to break through the limit has attracted attention.

Optical devices able to achieve the ultra-fast and parallel processing required in next generation communications and computing are expected to have various functions more than the electronic devices. Nonlinear photonics materials are new advanced optical functional materials on the basis of nonlinear optics in atomic or molecular level.

This research program aims to develop photonics materials available to logical devices that exhibit highly efficient photonics functions, such as large nonlinear susceptibility, fast response speed, physical stability, and so on.

Contents of Research and Development

(1) Elucidation of mechanism for the nonlinear optical phenomena

Elucidate various nonlinear optical effects, such as wavelength conversion, refractivity change, absorption change, stimulated scattering, and so on. Investigate the time dependent phenomena, such as the response speed, the relaxation, and so on, from the point of view of functional materials.

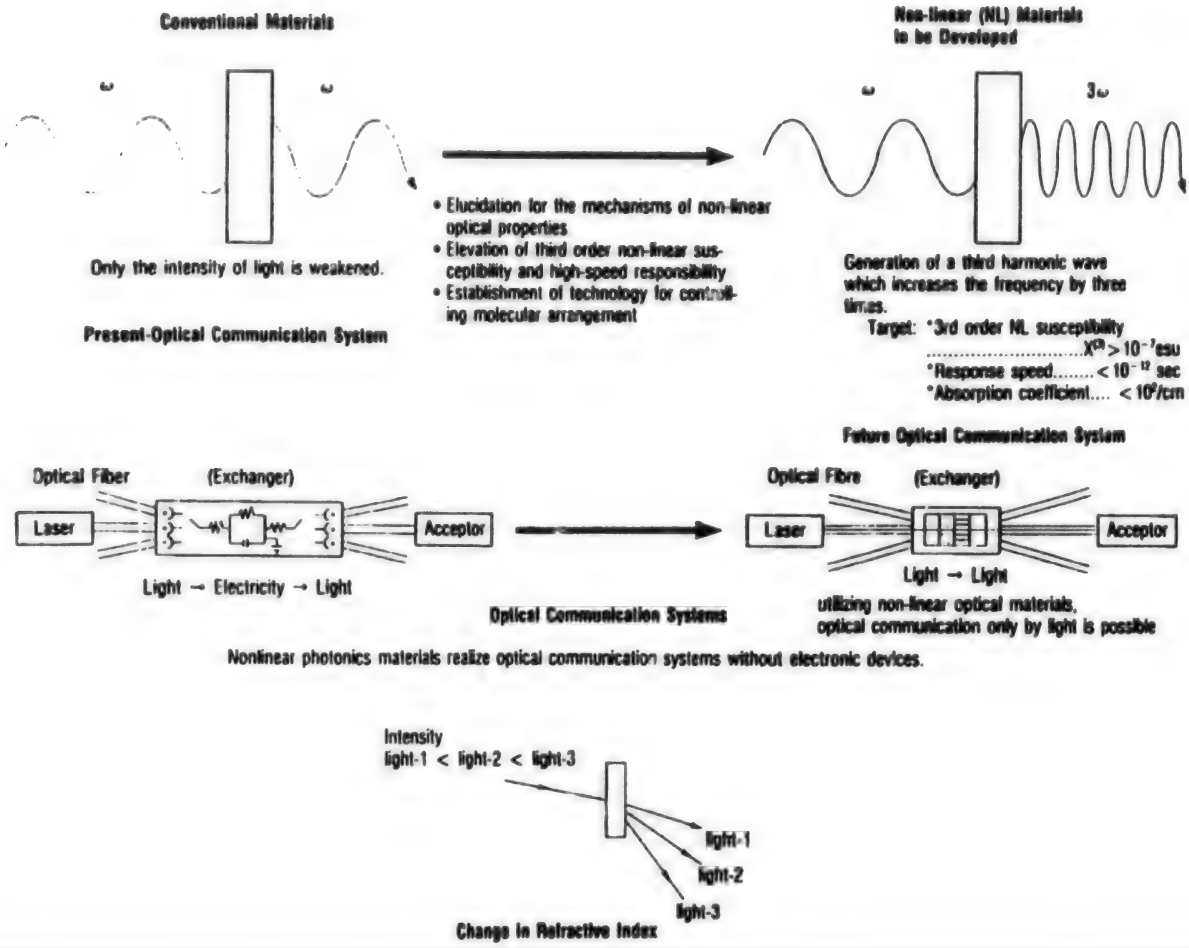
(2) Development of materials

1) Organic materials

Research on monomer, oligomer and polymer materials showing a large optical susceptibility with fast response. And development of the synthetic technology.

2) Dispersed materials

Research on dispersed materials showing a large optical susceptibility with fast response. And development of the synthetic technology.



(3) Development of material processing technology

1) Orientation controlled crystallization

Development of the crystallization technology for organic nonlinear photonics materials.

2) Dispersion

Development of the technology to disperse regulated fine particles uniformly in high concentration.

3) Superlattice

Development of the technology to prepare two or three dimensional superlattices.

(4) Development of evaluation technology

Development of the technology to evaluate nonlinear photonics material properties, such as structural properties, nonlinear optical constants, response time, and so on.

Advanced Chemical Processing Technology (1990-1996)

Purpose of Research and Development

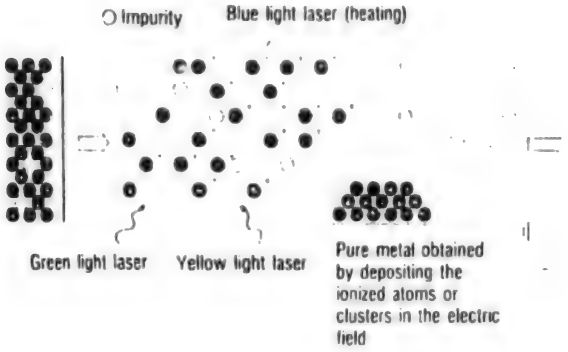
Recently, rapid progress of the technology for electronics, aerospace, medicine, energy, and others makes strong needs for the new materials with advanced functions and high efficiency. Also the new social problems that are a rapid increase in elderly people population, environmental protection, and a great increase in energy consumption have been expecting the advanced functional materials, such as good biocompatible and durable materials, advanced catalysts effective for environmental protection, new materials for high efficient power generator to contribute to the stable electricity service, and high corrosion resistant materials for producing petroleum.

This project aims to develop an advanced chemical processing technology to produce such highly functional materials described above by controlling their composition and structure to atomic or molecular scale.

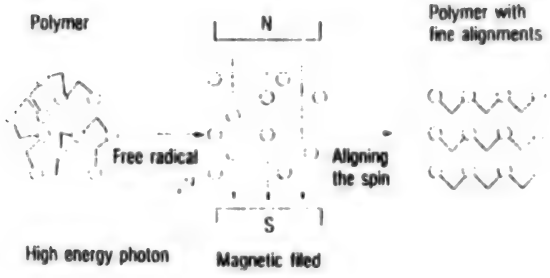
In order to meet these demands, research and development of three technologies:

(1) Ultra-high purification and separation processing technology;

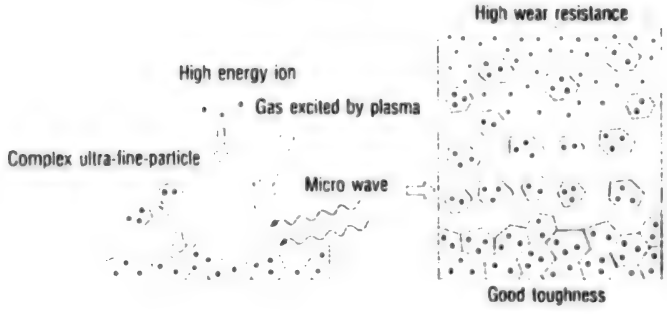
Purification by a Laser Induced Ionization



Polymer Preparation by Photochemical Processing



Inorganic Material Processing



(2) Inorganic ultra-fine-particle control technology;

(3) Synthetic technology for high-performance organic materials are being pursued.

Contents of Research and Development

(1) Development of processing technology

1) Ultra-high purification and separation processing technology

Development of the ultra-high purification process based on exciting the objective atoms by illuminating laser light followed by deposition of the ionized atoms or clusters in the electric field.

2) Ultra-fine-particle control technology

Development of the inorganic material process to control its structure and composition minutely by creating ultra-fine particle in the reaction field combined with plasma, molecular beam, accelerated ion, etc.

3) Synthetic technology for high-performance organic materials

Development of the photochemical process to synthesize new functional organic materials which are difficult to be synthesized by the conventional technique, under the reactive conditions of combined ultra-high pressure, ultra-strong magnetic field, ultra-low temperature, etc.

(2) Development of support technology

Development of the measurement and evaluation technology to optimize the processing and control of various reaction conditions in creating advanced functional materials.

Silicon-Based Polymers (1991-2000)

Purpose of Research and Development

Carbon-based polymer materials have been extensively developed as functional and structural materials since they allow versatile molecular design. However, faced by the ever increasing demand for superior physical properties and functions, an argument on the limitation of the carbon-based polymer is now emerging. Silicon-based polymers are highly innovative to meet the demand and are expected to have very wide range of applications.

However, technologies for the molecular design and the synthesis of silicon-based polymers are still in the cradle and are not extensively utilized as industrial materials.

In this project, basic technologies such as synthesis of new polymers, material processing, and evaluation techniques are developed to create a new class of silicon-based polymers that are able to exhibit superior electronic and optical functions and mechanical properties as compared with the carbon-based polymers.

Contents of Research and Development

(1) Molecular Design and Synthesis Technologies

1) Molecular design and structure control

Basic technologies of the molecular design are developed for the control of the main and side chain structures, multi-dimensional framework, molecular weight and molecular weight distribution, and higher order structure that are prerequisite to create silicon-based polymers with high performance and functions.

2) Monomer synthesis

Organosilicon monomers are designed and synthesized for condensation, addition, and ring-opening polymerization reactions.

3) Polymer synthesis

A wide range of new polymerization such as dehydro-coupling of hydrosilanes are developed. The methodologies for introduction of multi-dimensional structure and functional groups, and for crosslinking and other structural modifications are also exploited to functionalize the silicon polymers.

(2) Material processing technologies

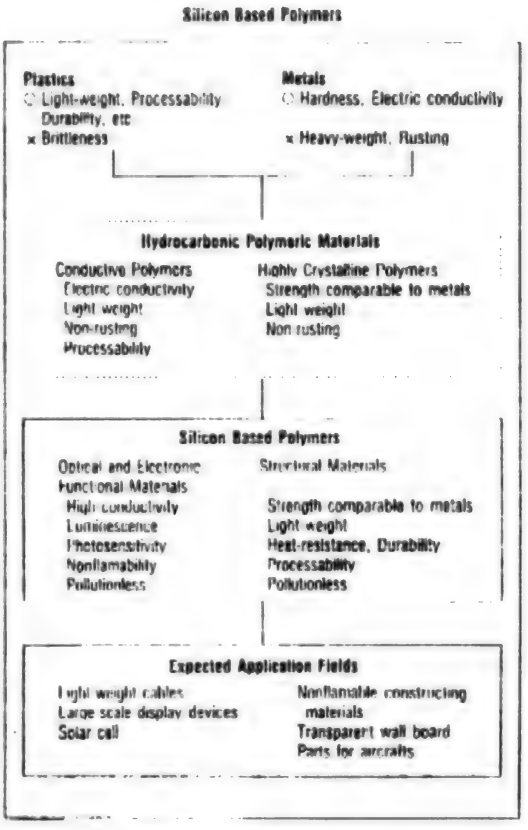
To efficiently utilize the molecular characteristics, the technologies for material design, higher order structure control such as molecular arrangement, hybridization, thin-film-making, elongation, and other processing to improve the performance.

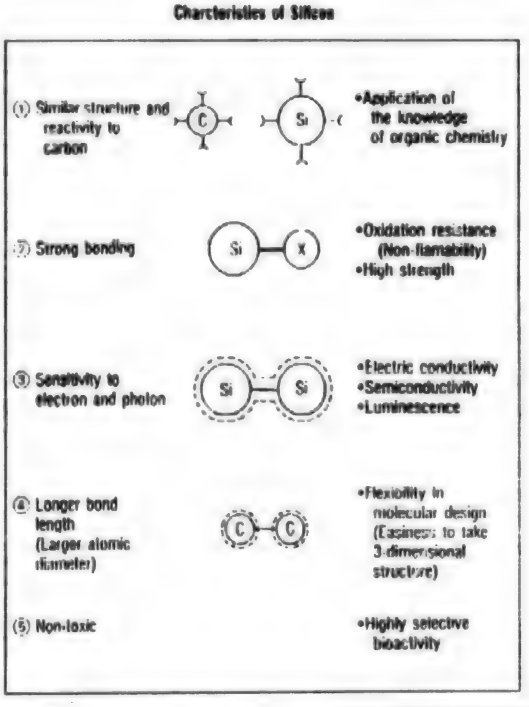
(3) Evaluation technologies

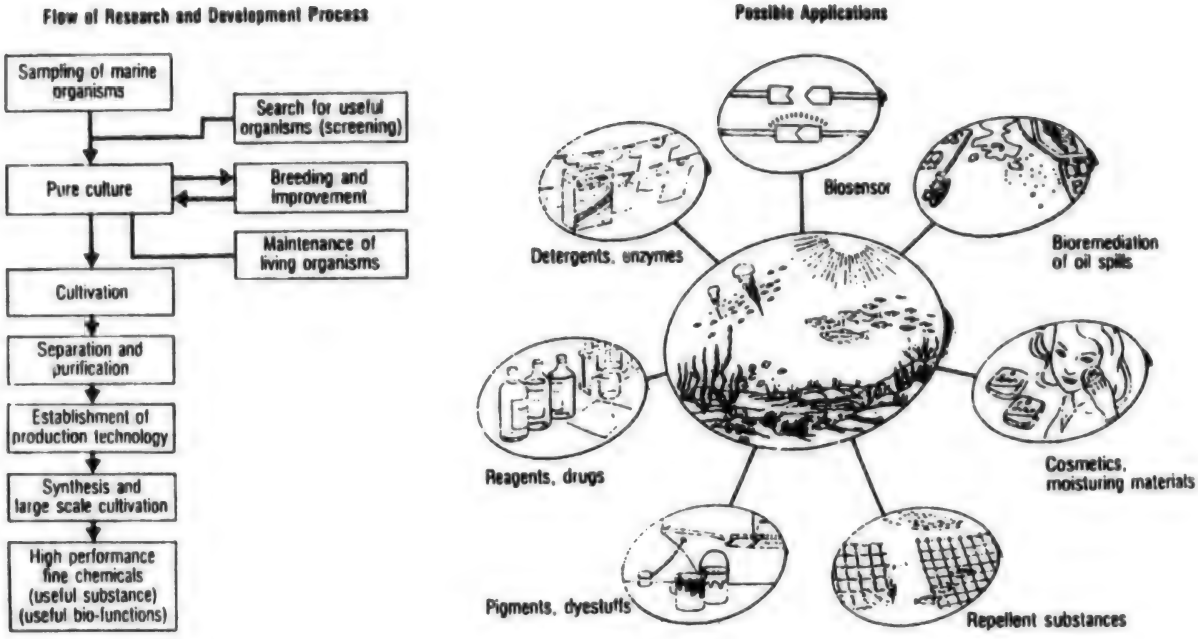
In view of the monomer synthesis, polymer synthesis and material processing technologies, the structures and properties specific to the silicon polymers are analyzed and evaluated.

Biotechnology

In 1980's new biotechnology such as recombinant DNA technology had made great strides and researches in variety of fields of biotechnology were carried out all over the world. Following the rapid technological innovation of 1980's, construction of new technological framework in biotechnology is expected in 1990's. This includes fundamental researches such as elucidation and utilization of unknown functions of living organisms, new research and development with global point of view such as conservation and utilization of wide variety of







genetic resources of living organisms, and fundamental and innovative researches based on a new concept.

Marine Biotechnology (Fine Chemicals From Marine Organisms) (1988-1995)

Purpose of Research and Development

Japan has the sixth largest exclusive 200-miles economic sea area in the world. Toward the coming 21st century, Japan is expected to be a leading nation in the field of research and development of marine bio-resources through the intensive utilization of highly advanced biotechnology. Biotechnology has so far been developed based on the research of terrestrial organisms, which are relatively easy to access. However, the ocean is supposed to be the place where the first life system was originated and marine organisms far exceed terrestrial organisms in both total mass and diversity.

On the other hand, there are a lot of difficulties to overcome in the sampling and maintenance of marine organisms, because the conditions such as pressure, temperature, oxygen concentration, and light intensity in marine environments are totally different from those in terrestrial environments. Conventional technological methods which have been developed for terrestrial organisms are not directly applicable to marine organisms. New technology including such as fermentation methods, gene manipulation methods, and cell fusion methods which work under higher salt concentration have to be established.

The goal of this project is to search and elucidate biological phenomena of marine organisms and to develop basic technologies for the utilization of various marine bio-resources.

Contents of Research and Development

In order to develop basic technologies for the utilization of various marine bio-resources, for example the production technology of useful chemicals such as coating materials for underwater structures, pigments, dyestuffs, and moisturing materials, the following research and development activities are being carried out.

(1) Basic technology for utilization of marine organisms

(2) Production technology for useful chemicals

(3) Utilization technology for useful bio-functions of marine organisms

(4) Supporting systems

(5) Technology for bioremediation of oil spills

(6) Antifoulding [as published] technology

Molecular Assemblies for a Functional Protein System (1989-1998)

Purpose of Research and Development

Basic technologies for artificial reconstruction of functional protein assemblies are to be developed. In industrial applications, the technologies would make it possible to artificially reconstitute the complex functions of the functional protein assemblies of living bodies. This should enable self-controllable chemical reaction processes, selective and specific multi-stage reaction, etc.

Contents of Research and Development

Protein suitable for artificial reconstruction will be screened from functional protein assemblies in biomembrane, and basic conditions for analyzing their function and structure will be established. The elementary technologies necessary for artificial reconstitution of functional protein assemblies will be established. Finally, functional protein assemblies will be reconstituted, and their function and structure will be evaluated. To achieve these objectives, following 5 research activities are in progress.

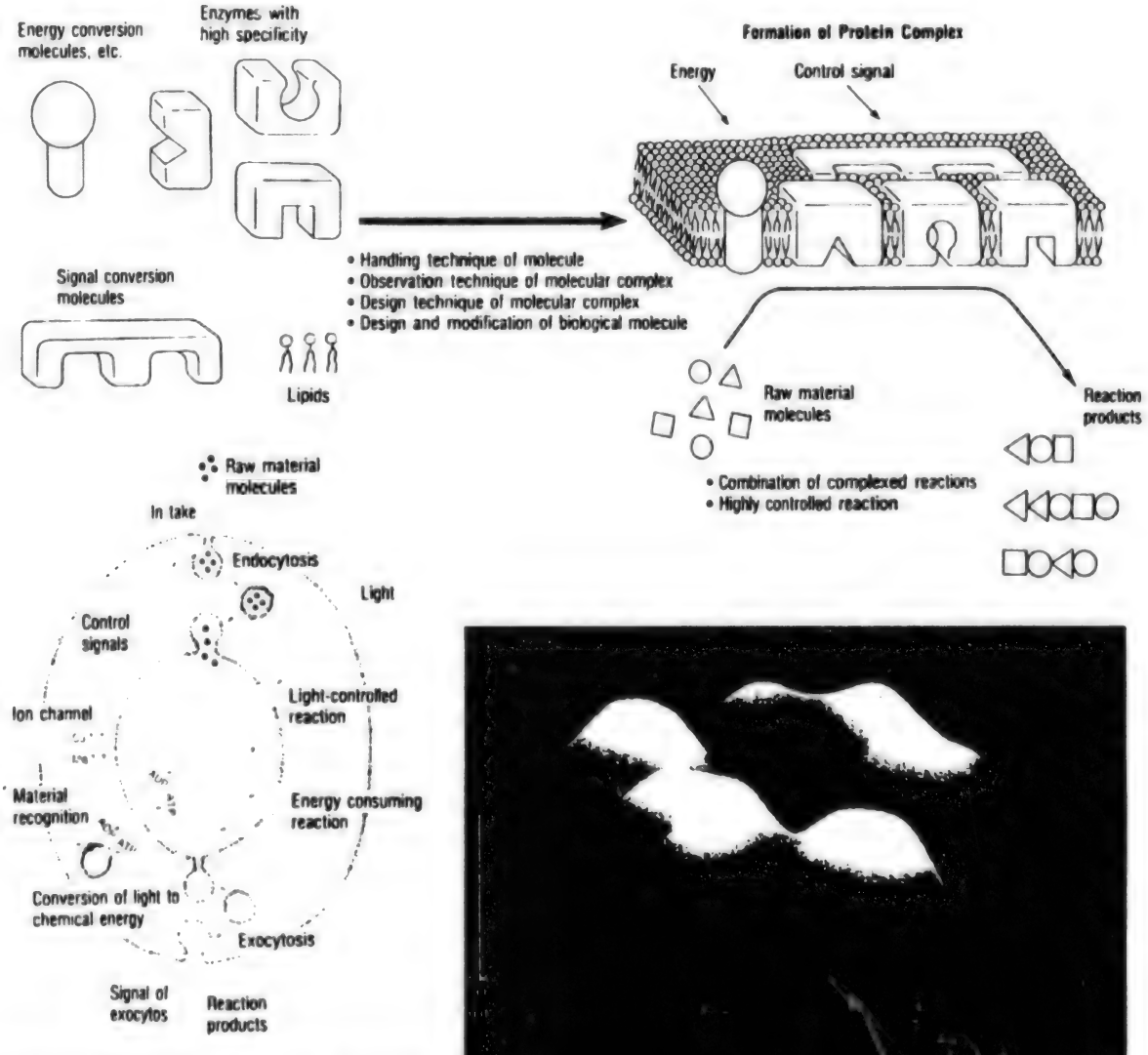
(1) Analysis of the structure and functions of the assemblies in organisms, and evaluation of their functions.

(2) Extraction, separation and purification of assemblies from biological materials.

(3) Stabilization and modification of functional proteins and lipids, and development of artificial materials with functions.

(4) Artificial reconstitution of assemblies.

(5) Evaluation of artificially reconstituted assemblies.



Possible Molecular Assemblies for a Functional Protein System

A STM Image of F_1 subunits of H^+-ATPase

Production and Utilization Technologies of Complex Carbohydrates (1991-2000)

Purpose of Research and Development

The project aims to establish basic technologies for using complex carbohydrates industrially which are basic substances in organisms and have important functions such as substance recognition.

Contents of Research and Development

Complex carbohydrates are expected to play important roles in industry. Technology for synthesizing complex carbohydrates based on chemical and biological approaches and remodeling technology for creating complex carbohydrates with artificially designed structure are to be developed.

For this reason, following research activities are advanced.

(1) Chemical approaches

1) Synthesis based on chemical approaches

2) Binding and utilization of sugar chains

3) Molecular design of complex carbohydrates

(2) Biological approaches

1) Production and utilization by animal cells

a) Utilization of adherent cells

b) Utilization of floating cells

2) Production and utilization by yeast

a) in vivo remodeling technology

b) in vitro remodeling technology

3) Analysis of structure of sugar chains

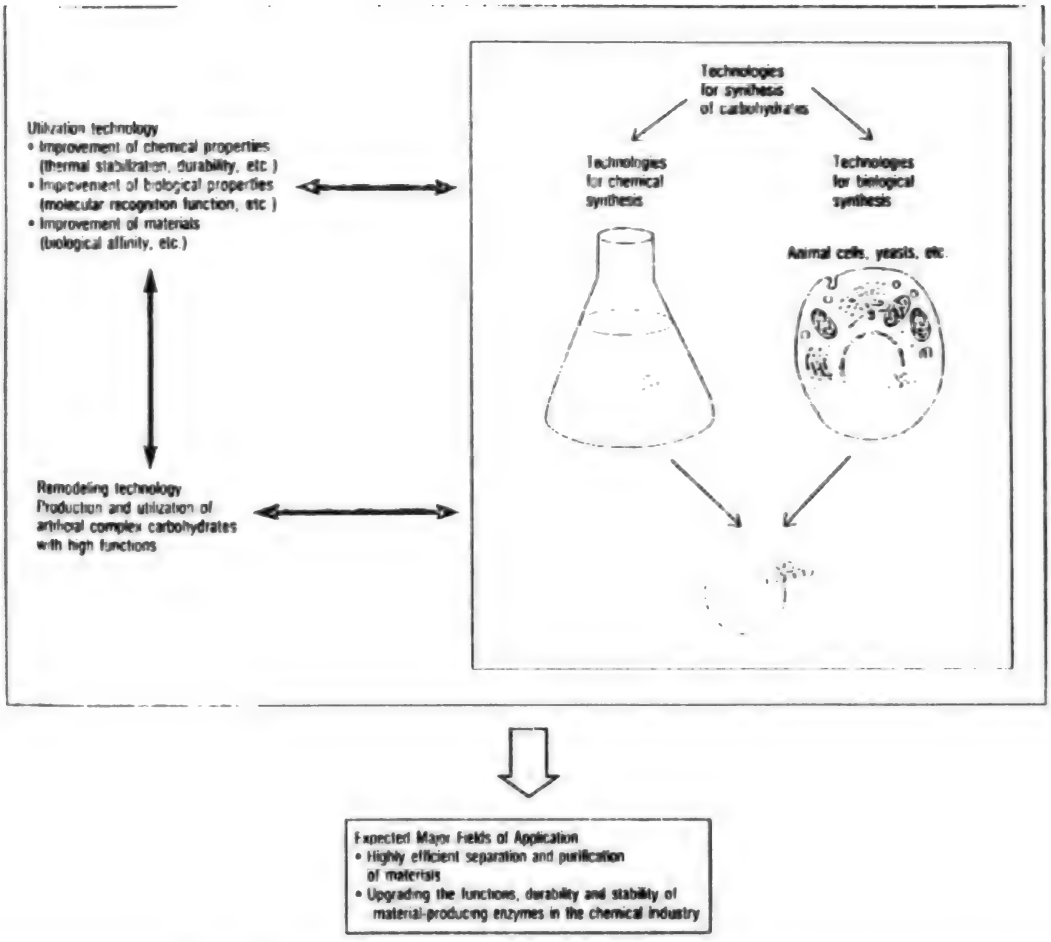
Utilization of lectins and monoclonal antibodies

(3) Remodeling technology

Through these research activities, technology will be developed for remodeling complex carbohydrates (creation of highly functional complex carbohydrates which are not present in nature).

Electronics, Information and Communication

Now that "electronics revolution" has entered a stage of broader dissemination and maturation, the importance of technological development in fields of electronics, information, and communications is ever growing. The construction of sophisticated information-oriented community pursuing true richness in harmony with environment urgently requires fundamental and creative R&D efforts. In order to achieve certain breakthrough in those technologies, which are supposed to approach a limit in view of existing trends, active research and development are being conducted in fields of technology to handle infinitesimal domains, both temporal and spatial, technology to implement superb biological functions in engineering, and versatile software technology to make development and maintenance extremely easy.



Bio-Electronic Devices (1986-1995)

Purpose of Research and Development

Living bodies have excellent information processing devices and functions such as memory, learning, and pattern recognition on living brains. By applying such bio-information-processing methods to the engineering field, it is possible to achieve new concepts and implementation of information processing beyond the literature of semiconductor technologies.

We have two approaches to the goals: First, research on analyzing and elucidating the mechanisms of memory, learning, and pattern recognition in neural activities and its applications into engineering are carried out. Second, bio-electric devices which have the functions of living bio-molecules are to be developed and evaluated.

Contents of Research and Development

The following research and development are carried out in order to design, construct, and evaluate the prototype of bio-electric devices.

(1) Technologies for analyzing and elucidating neural activities and information processing methods in living bodies

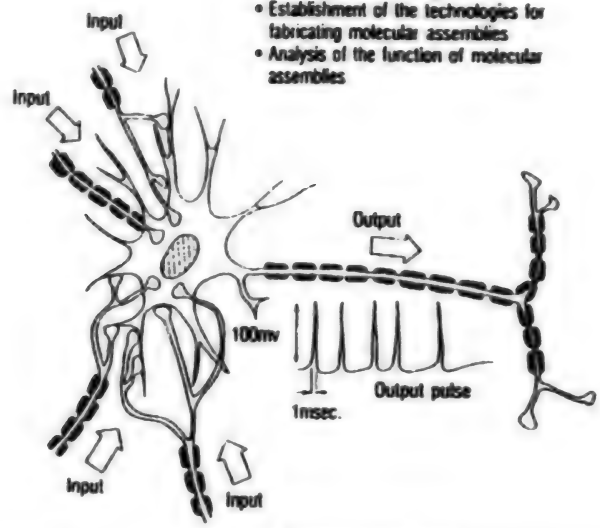
(2) Technologies for constructing and evaluating the high-quality information processing mechanisms in living bodies

(3) Technologies for fabricating and evaluating the signal transformation mechanisms of molecular assemblies

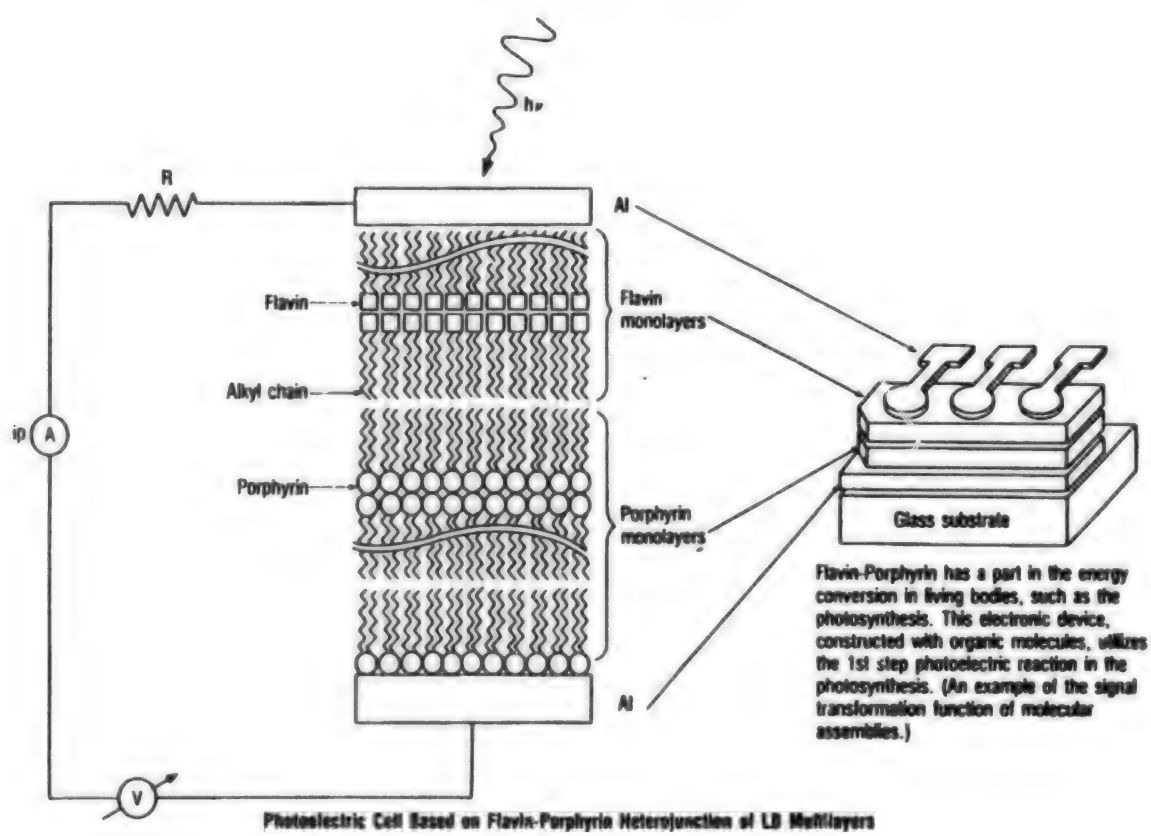
(4) Technologies for fabricating and evaluating the bio-electric-devices constructed by molecular assemblies

New information processing technologies developed for memory, learning, and pattern recognition functions are expected to be a key to the realization of bio-computers in the future.

- Elucidation of basic principles of operation and memory functions in the neural cell system
- Modeling of a neural system
- Establishment of the technologies for fabricating molecular assemblies
- Analysis of the function of molecular assemblies



A Model of a Neural Cell



Flavin-Porphyrin has a part in the energy conversion in living bodies, such as the photosynthesis. This electronic device, constructed with organic molecules, utilizes the 1st step photoelectric reaction in the photosynthesis. (An example of the signal transformation function of molecular assemblies.)

Photoelectric Cell Based on Flavin-Porphyrin Heterojunction of LB Multilayers

New Models for Software Architecture (1990-1997)

Purpose of Research and Development

New models for software architecture to be developed which flexibly and automatically adapt to changing circumstances through cooperative problem-solving functions of software modules.

Contents of Research and Development

(1) Research and development on analysis and modeling of a cooperative problem solving process

  (a) Research on analysis and modeling of a cooperative problem solving process which optimizes cooperation among software agents

  (b) Research on analysis and modeling of cooperative problem solving processes which optimize cooperation between human and software agents

(2) Research and development of the basic mechanism for cooperative architecture

  (a) Research on mechanism of understanding messages with respect to situation (situational reasoning)

  (b) Research on the mechanism of changing memory structure according to situation change (self-reorganization of knowledge representation)

  (c) Research on the mechanism with which each agent autonomously allots and executes processing in an optimal way (cooperative computation)

  (d) Research on the mechanism of taking correspondence of inputs and outputs between agents (semantically adaptive software modules)

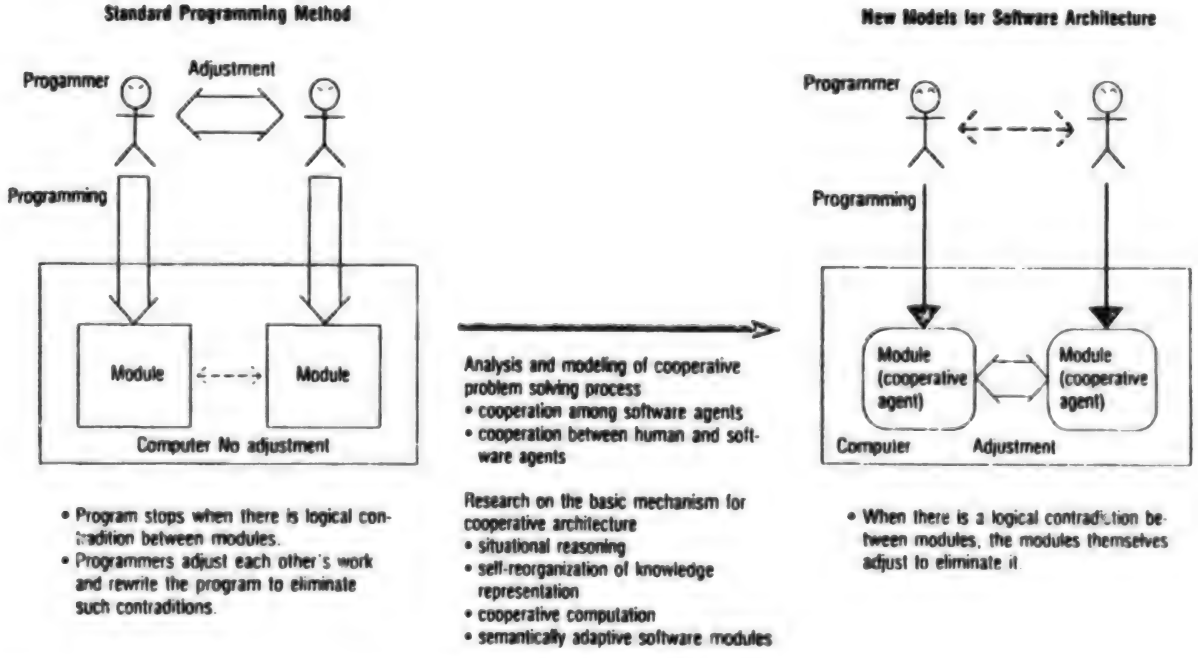
This new model for software architecture is expected to be a key technology for software which enables programs:

1) to make system development easier;

2) to make system maintenance easier;

3) to satisfy various needs,;

4) to handle unexpected situations.



Quantum Functional Devices (1991-2000)

Purpose of Research and Development

As we move toward a highly developed information society in the 21st century, ultra-high speed and ultra-large capacity information processing systems are indispensable. Si LSIs, which are key components in a data processing system, have made remarkable progress by the miniaturization of element devices. Stepping into the mesoscopic realm in fabrication size, conventional semiconductor devices can not work well due to the appearance of quantum phenomena. In order to overcome the problem, it will be necessary to control quantum effects such as electron tunneling, electron wave interference, and energy level quantization and to pursue operational principles of devices based on quantum effects. The purpose of this project is to establish basic technologies for developing innovative devices with ultra-high speed and multi-functions by utilizing quantum effects appearing in ultrafine structures.

Significantly improved performance of electronic devices including ultra-high speed, ultra-large scale integration, and lower power consumption is expected. The results are expected to be extensively used in such applications as ultra-high-speed, large-capacity computer system, ultra-high-speed, high-accuracy image processing, subminiature, high-performance automatic translation machines, and ultra-high-speed, high-accuracy simulation.

Contents of Research and Development

(1) Basic technologies for utilizing various quantum effects

1) Fabrication and characterization technology of ultrafine electrical structures

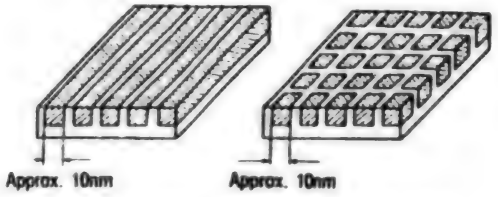
2) Basic technology for controlling quantum functions

(2) Device application technologies of quantum functional devices

1) Fabrication technology for element devices utilizing quantum effects

2) Integration technology for quantum functional device systems

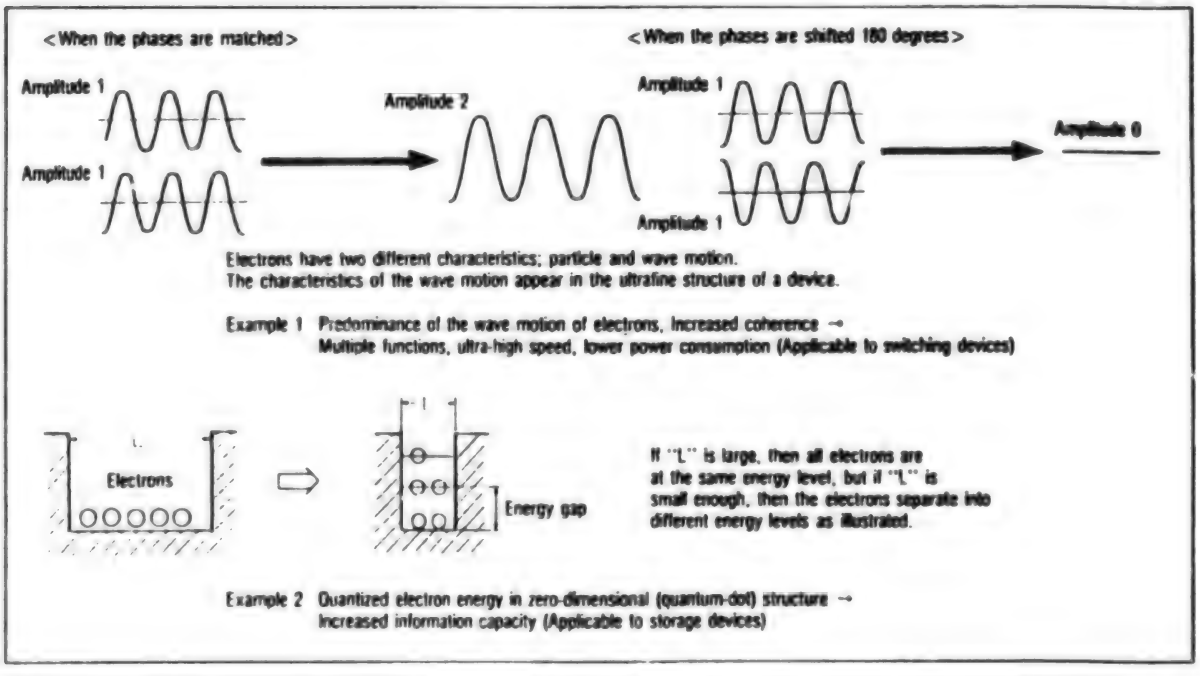
Basic Conceptual Diagram of a Three-Dimensional Quantum Microstructure



(A) Quantum wire (B) Quantum box

• When electrons are confined in a quantum wire or quantum box whose sectional dimension (about 10nm) is similar to the electron wavelength, the quantum effects become conspicuous.

Quantum effects utilized for quantum functional devices



Ultimate Manipulation of Atoms or Molecules (1992-2001)

Purpose of Research and Development

Recent quick-paced progress in technology for observation and manipulation of nanometer-sized entities has enabled to expand the degree of freedom for technological development in such fields as new materials, chemistry, electronics, biotechnology, and so on. The frontiers of these fields are currently shifting from sub-micron to angstrom scale, and it is desired to refine the technique of probing and controlling so as to cover ultramicroscopic region allowing direct recognition of atoms and molecules. Under these circumstances, the present R&D project concerns the establishment of technology for precise observation and manipulation of single atom or molecule on the surface of matter or in free space and its supporting technology. This technology is expected to serve as a common, basic technology for different fields of industrial technology.

Contents of Research and Development

(1) Technology for observing and manipulating atoms and molecules on solid surface

1) To pursue R&D of technology for observing, measuring and manipulating atoms and molecules on the surface of various matters or materials under various conditions.

2) To pursue R&D of technology for measuring, analyzing and controlling dynamic features of process such as chemical reactions on solid surface in real time.

(2) Technology for observing and manipulating atom assemblies in space

1) To pursue R&D of technology for observing and measuring in situ of formation, association, dissociation and reaction of atom assemblies in free space.

2) To pursue R&D of technology for controlling motion and reaction of atom assemblies and electron transfer between atom assemblies, and for building a self-organizing assembly structure.

(3) Technology for observing and manipulating structure of organic molecule

1) To pursue R&D of technology for identifying individual organic molecules and observing and manipulating chemical bond and electron state at a specified site of molecule.

(4) Theoretical analysis of atomic and molecular processes

1) To pursue R&D of technology for theoretically analyzing adsorption, release, diffusion and reaction processes of individual atoms and molecules on solid surface.

2) To pursue R&D of simulation technology for precisely predicting atomic and molecular processes and their characteristics on purely theoretical basis.

The present R&D project is expected to exert the following effects.

1) Conducting research for seeking possibilities of creating new materials of structure controlled at atomic and molecular levels and producing novel physical phenomena never encountered in nature, as a world center of excellence (COE), will stimulate basic and creative research in Japan and contribute to the international science communities.

2) Discoveries of new magnetic, electrical and chemical properties will enable us to develop innovative materials and substances different from existing ones and provide long-term, basic technologies to support the future of new materials, chemistry, electronics, biotechnology and other fields.

3) To be more specific, problems of resources, energy and environment will be solved through R&D of basic technologies for creating materials of excellent refractoriness, abrasion resistance, and anticorrosiveness, as required by power generating facilities, and those for accelerating and improving accuracy of analysis of biological components, such as gene structures.

Machinery and Aerospace

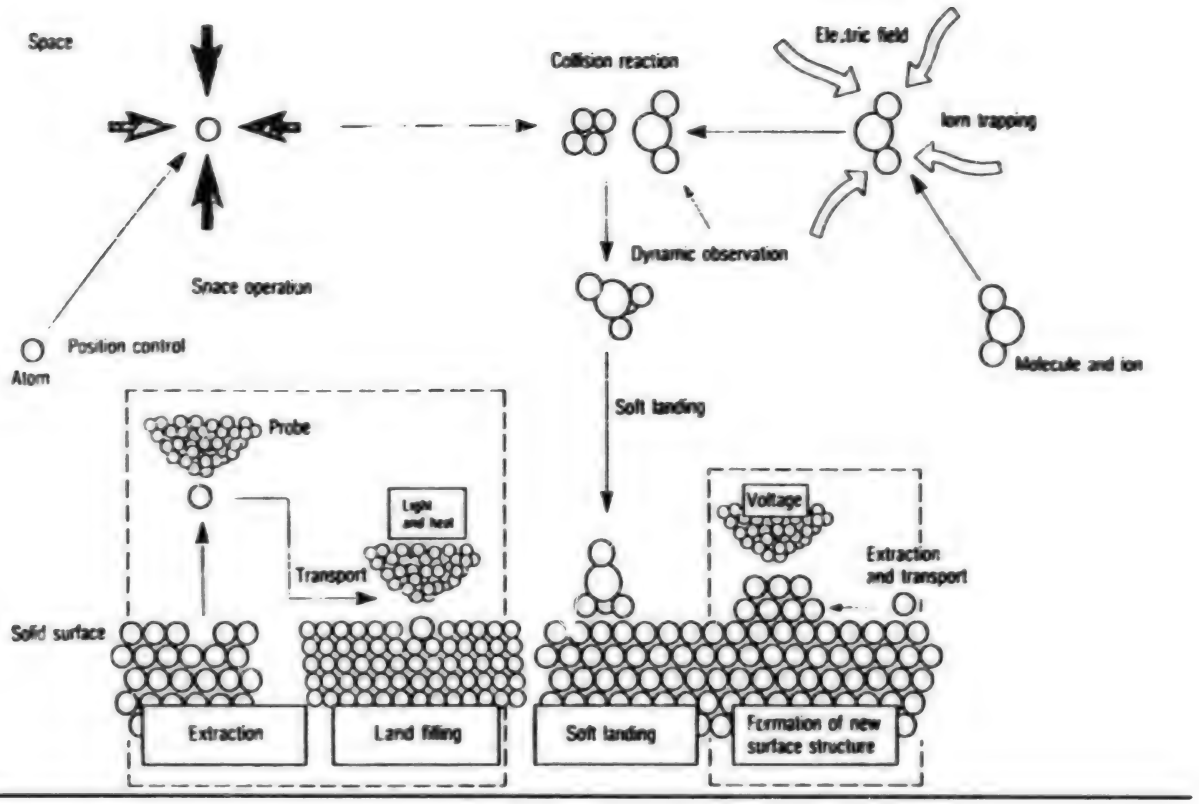
Since industrial revolution started, machinery and aerospace technologies have been constantly developed and the importance of this field is increasing as a key technology which build the 21-century world for comfortable, safe and convenient life of people.

We will try to develop smaller and lighter machine, which also have higher speed and more functions by doing scientific research of physics, biology and chemical phenomenon and its application, and it is also desired to develop new technology with human sense and experience. And it is expected that technology development which harmonize with human, social life and environment will be achieved by synthesizing these technologies.

Advanced Material-Processing and Machining System (1986-1993)

Purpose of Research and Development

In the field of advanced technology which will support the future of Japan, such as energy, precision machine, electronics, aerospace and so on, it is being difficult to improve ability of machines which was required for advanced technology industry, because the specifications of material become higher and new hard-to-machine material is being used.



On the other hand, the application of energy beams such as excimer laser and ion beam to precision machining technology or usage of the parts machined by these beams or new concept machining equipment may make it possible to achieve ultra precision machining by a totally new method.

In this situation, it is the subject of this R&D project to develop high-power excimer laser equipments, high energy ion beam equipments and ultra-precision machining equipments to enable the ultra precision machining which is required by advanced technology industry, and to develop advanced material processing and machining technology using these equipments and measurement and evaluation technology which support them.

Content of Research and Development

(1) R&D on advanced material processing and machining equipment

1) R&D of excimer laser technology

Development of high-power, high-repetition and long-life excimer laser technology which enables various kinds of surface processing with chemical reaction caused by high photon energy emitted in the ultra-violet region.

2) R&D of ion beam technology

Development of focused, clustered and wide-range energy ion beams and of large current, high energy ion beam technology which creates durable material surfaces for corrosion and wear and heat-resistant surfaces.

3) R&D of ultra precision machining technology

Development of ultra precision machining technology for highly efficient, highly accurate processing with nanometer-order of complex, three-dimensional parts by using in-process sensing and other new technology.

(2) R&D on advanced material processing technology

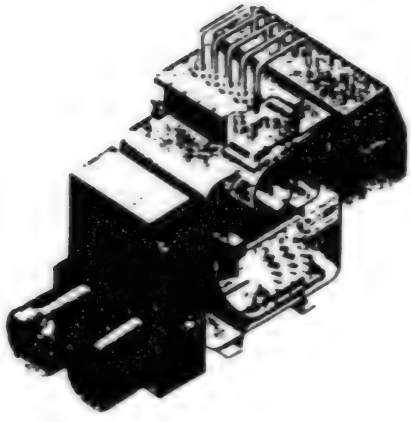
Development of advanced material processing technology employing excimer lasers and ion beams.

(3) R&D on supporting technology

R&D of ultra precision measurement and evaluation technologies for support of advanced material-processing and machining technology.

(4) R&D on total system technology

Development of a total, interactive system concept. Design of tests for advanced material-processing and machining system.



High Power Excimer Laser

An excimer, short for "excited dimer", can exist only in an excited energy state, making it possible for its use in the generation of high power, short pulse laser beams. Excimer lasers emit lights in the ultra violet region. The photon energies of the laser beams are high enough to selectively and efficiently activate chemical bonds, and the laser beam can be focused to the order of submicron so as to perform microfabrication or micro-lithography.

Ion Beam Equipment

Ion beams can be formed by ionizing various types of elements and molecules to be collimated under acceleration by an electric field. Ion beams are not only energy sources but also material sources. By performing ion beam deposition or implantation through controlling the beam's energy, every material can be put on or into other materials at the desired depth from the surfaces. In this way, extremely high quality multi-layers or modified surface layers with numerous functions can be formed on ordinary materials.

Super/Hyper-Sonic Transport Propulsion System (1989-1998)

Purpose of Research and Development

Rapidly increasing demand for high speed air transportation spurs the development of a super/hyper-sonic transport (or SST/HST).

Based on recent technology developments, a super/hyper-sonic transport system which can fly from Tokyo to New York in three to five hours, is expected to be in the early 21st century.

The propulsion system is one of the key areas among the highly advanced technologies needed for the SST/HST.

This research and development program aims to integrate a "Ramjet" and a "High Performance Turbojet" into the single propulsion system called a "Combined Cycle Engine".

Content of Research and Development

The goal of the ten year program is to demonstrate the new concept engine's high performance, including its fuel efficiency and environmental acceptability throughout Mach 0 to 5.

In addition, research and development of a high efficiency power generating gas turbine is also carried out in this project. The raising of gas temperature is of increasing interest that has close relation with the turbojet.

The following are the major goals of the program.

(1) Research and development of a high-efficiency/high-power ramjet which realizes reliable operation at about Mach 5.

(2) Research and development of a high-efficiency/high-power turbojet with a reasonable size for integration with the ramjet.

(3) Research and development of a measurement and control system which will provide highly advanced and effective measurement and control of the entire engine.

(4) Research and development of a total system, including the establishment of the most effective integration of subsystems with a variable geometry.

(5) Research and development of a super high temperature gas-generator which will be installed as a core of the power generator.

Micromachine Technology (1991-2000)

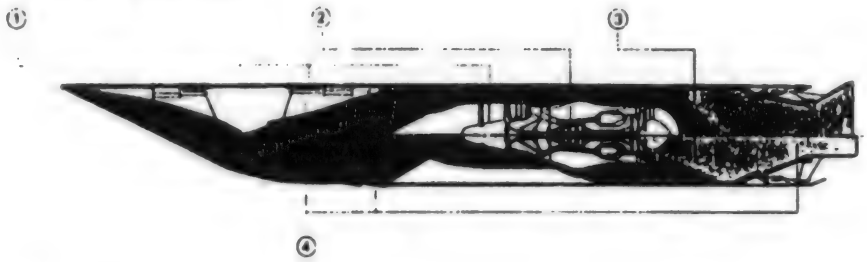
Purpose of Research and Development

Power plants, jet engines, and other large complex industrial systems must meet the two contrary requirements of further improving reliability and reducing maintenance cost.

Establishment of the new technology is desired by which the complex systems will be inspected and repaired in the restricted spaces inside the systems without disassembling them.

One of the important problems for elevating the level of medical treatment is reducing pains incidentally to diagnosis and treatment to a minimum level. Development of new medical equipment technology is also required by which diagnosis and treatment will be achieved from inside the body to minimize the surgical operation.

Combined Cycle Engine Concept



① CONTROL & MEASURING SYSTEM RESEARCH
Research on control and measurement for engine system to achieve high performance, high power and high reliability

② TURBOJET RESEARCH
Research on turbojet engine as the core of the turbo-ramjet engine with high performance

③ RAMJET RESEARCH
Research on Ramjet Engine enabling the stable flight on Mach 5 with high performance

④ TOTAL SYSTEM RESEARCH
Research on optimum integration of turbojet and ramjet engine, variable mechanism of intake and exhaust nozzle and noise reduction, etc.

Operating Condition of Ramjet
(OVER MACH 3)

Operating Condition of Turbo-Jet
(UNDER MACH 3)

The final target of this project is to establish a micromachine technology system composed of microscopic functional elements, capable of moving both in complex devices like power plants and in narrow parts of living bodies and performing a particular work on its own.

Content of Research and Development

(1) Microcapsule

R&D of the element technologies and the systematization technologies for the capsule-type micromachine which will drift in the water flow and detect the position of flaws on the pipes will be carried out.

(2) Mother ship

R&D of the element technologies and the systematization technologies for the micromachine which will act as a mother ship, transporting inspection and operation modules near the flaw position, supplying the energy to both modules and acting as a communication link between the modules and outside control center, will be carried out.

(3) Inspection module without wire

R&D of the element technologies and the systematization technologies for cableless micromachine which will move inside pipes, inspect and analyze flaws in detail and report the results to the outside control center through the mother ship will be carried out.

(4) Operation module with wire

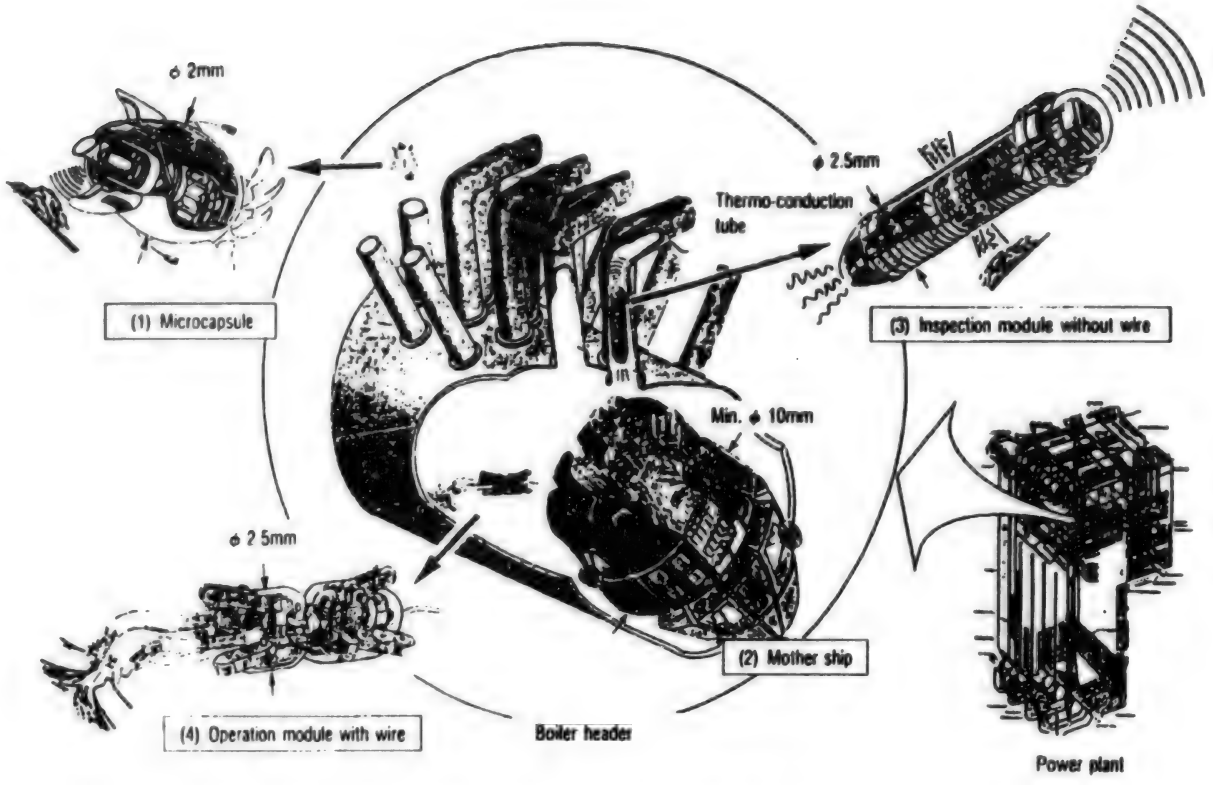
R&D of the element technologies and the systematization technologies for cabled micromachine which will repair flaws and gather samples will be carried out.

(5) Total system

Research of the total micromachine system for industrial and medical use will be carried out.

Natural Resources

In the future, the weight of the exploration and development of underground resources, such as petroleum, coal, and minerals, is expected to shift to the wealth that has been difficult to discover and develop with conventional technology because of the complex structure and the depths of underground. Therefore, it is necessary to actively advance the research and development of the technology intended for accurately and efficiently estimating and detecting the positions of the resources existing in the depths of underground, and the technology for developing the deep-seabed



Advanced maintenance system for power plants

minerals and other resources that have already been discovered but are difficult to develop on a commercial basis for technological and/or economical reasons. Also, since natural resources originally are finite in quantity, it is important to develop their advanced utilization and re-utilization technology that is highly efficient and provides maximum environmental protection.

Manganese Nodule Mining System (1981-1996)

Purpose of Research and Development

Manganese nodules containing nickel, copper, cobalt, and manganese have been found spread over wide regions of the floor of the Pacific and also in several other areas of the world's oceans where waters depth ranges from 4,000-6,000 m. Though these metals are essential and dispensable resources for human life and industrial activities, the land based reserves of these metals are unequally distributed and gradually being depleted.

Manganese nodule deposits are found worldwide on the ocean bed in international waters in large quantities. They can be thought of as attractive and stable resources, economically. From this point of view, new technology for mining manganese nodules from the deep ocean floor needs to be developed.

Content of Research and Development

This research and development project is developing the mining system technology for mining manganese nodules from deep seabeds using a highly efficient and highly reliable fluid dredge process. This project is also developing the technology for offshore oil field development in deep water.

(1) The mining system consists of a total system and subsystems, and based on conceptual design, element technology development operations and function verification tests will be performed to establish the fundamental technology required for mining test.

(2) For offshore oil field development technologies, the technological development and functional verification tests for handling and gas-lift of system will be performed to establish the fundamental technology required for verification test in the ocean.

(3) After the manufacturing of testing equipment based on the results of items (1) and (2) above, the ocean test will be conducted to establish technology.

An outline of the systems is given below.

1) Total system: Integrates the detailed design of each subsystem to achieve operational matching between the subsystems.

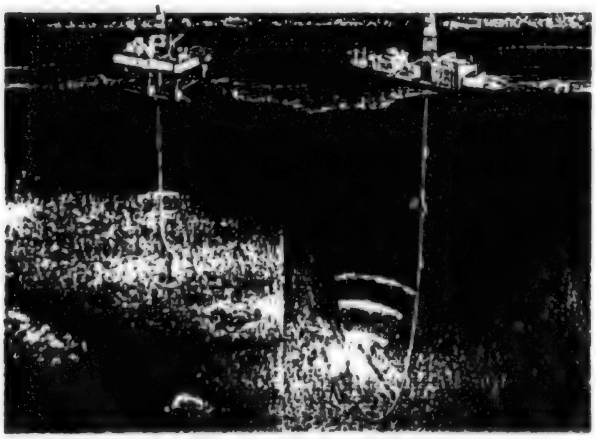
2) Collecting system: Collects manganese nodules with the towing type and size selecting type collector operated by fluid dredge process.

3) Lifting system: Transports collected manganese nodules perpendicularly to a mining ship.

4) Handling system: Suspends and tows submersible equipment from the mining ship. Also, lowers the equipment into the sea and recovers the equipment from the sea.

5) Measurement and control system: Provides data measurement as well as supervision and control of each system in integrated from during their movements from the seabed to the mining ship. [as published]

6) Research and development of offshore oil field development technologies: Handling technology for the lowering and recovering of submersible equipment into the sea and from the sea for oil field development in deep water, and gas-lift technology for artificial oil production using high pressure gas injection.



Human, Life and Society

To realize the society in which people feel comfortable and satisfied, new viewpoints are being introduced which puts emphasis on human beings and their life. In this trend, it is required to establish the basic science and technology directly related to human beings and their life. It is also necessary to break through the current technological restrictions into new frontier to enhance the human activities and to obtain variety in selection.

It is expected that these technologies will promote comfortable and satisfied society in which people enjoy self-realization by appreciating their own choice in selection based on the human-oriented technology.

Underground Space Development Technology (1989-1995)

Purpose of Research and Development

In Japan, dense national population (120,000,000) and narrow national land area (370,000 m^2) result in overpopulated conditions in areas such as those around large cities, and three-dimensional and synthetic utilization of unused spaces and preservation of environment become large subject to be researched. In these circumstances, deeper underground space (geo-front) is expected as a space resource (new frontier) to mitigate above conditions. For this purpose, technologies already established are insufficient, and therefore, it is expected that new technologies should be developed to construct and utilize underground spaces. Consequently, satisfied lives will be brought about by construction of life and social infrastructures using the technologies.

Content of Research and Development

Technologies are developed to construct and utilize an underground dome (50 m diameter, 30 m high, greater than 50 m below ground level), so that the underground space may prompt to be utilized as the life and social infrastructures.

(1) Geological survey and evaluation technology

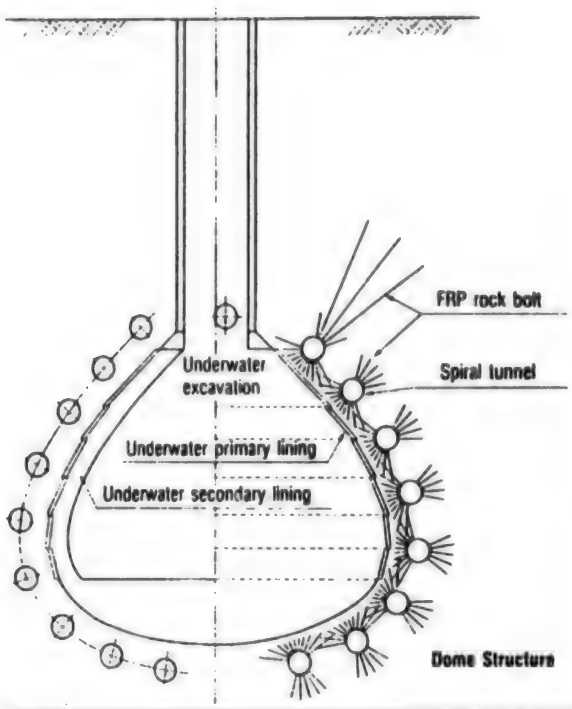
Crosshole tomography techniques based on CT scanning techniques put into practical use in the field of medical facilities will be applied to a survey and an evaluation for the underground structure by using elastic wave, electromagnetic wave and electric resistance. High energy oscillators, receivers and data analysis methods used for the techniques will be developed.

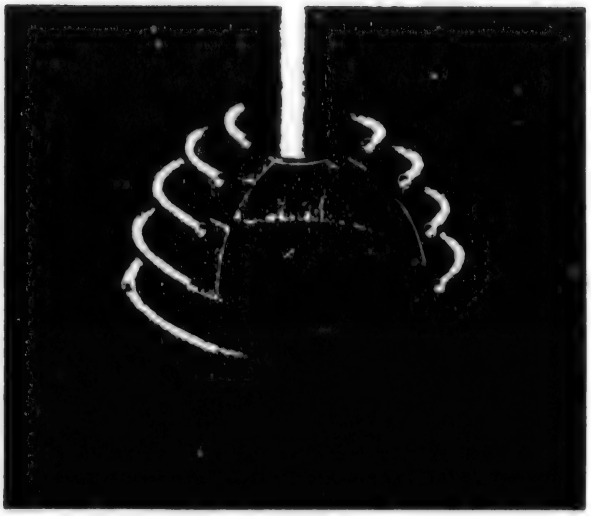
(2) Dome construction technology

In order to construct the underground dome, dome structure and construction technologies based on new conceptions will be developed. A machine and techniques necessary to construct the dome, such as a shield machine for sharp curved tunnels, rock-bolting techniques, and automated excavating and lining techniques for use in muddy water will be developed.

(3) Environment conditioning and hazard prevention technology

To overcome the disadvantages inherent to the underground and to secure safety, techniques for environment conditioning and hazard prevention will be developed.





Human Sensory Measurement Application Technology (1990-1998)

Purpose of Research and Development

In order to realize a more comfortable and satisfied life, we should stop our way of thinking such as pursuit for efficiency and convenience, or for enhancing productivity, improving functions, speed and capacity. Instead, we should change our viewpoint into human beings and their life.

For this purpose, it is necessary to develop new fundamental technologies such as understanding and serving for human beings and their life.

The purpose of this project is to establish basic technologies for human beings and their life through development of measuring technology of physiological and mental influence, through that of analysis technology for correlation between stimuli, responses and sensory factors.

In other words, this project is for both leading a more comfortable and satisfied life with user-friendly products and environment with less stress, and offering scientific indices for best individual selection.

Through offering the multi selection system for individual human being, that is, "Dynamism between proposition and selection", he will be able to establish himself by taking his best choice based upon scientific information for objective judgment.

Content of Research and Development

In order to improve daily-life products, working and living environments so that they reflect evaluation of human being, research and development have been carried out on technologies of easy and quantitative measurement of various human characteristics.

(1) Technology for measuring physiological influences

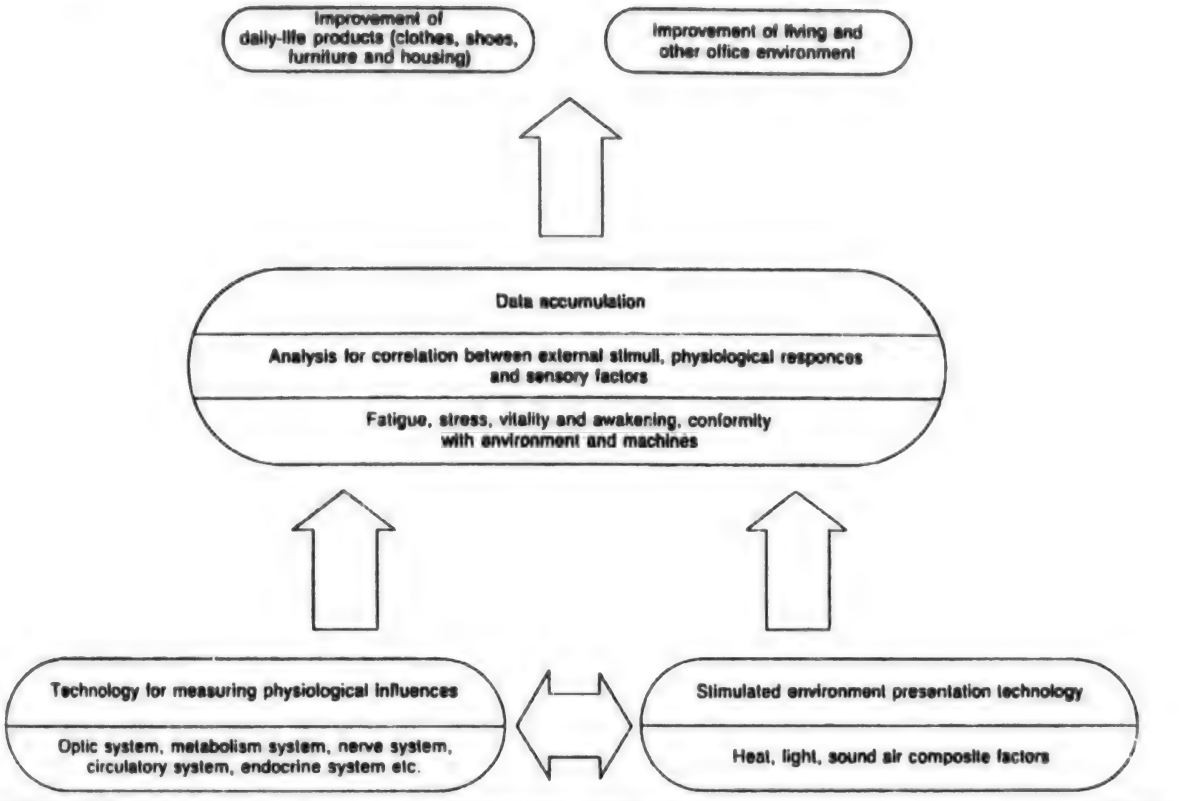
Physiological influence measurement technology which can easily measure physiological influences by detecting brain wave, stress hormone, without hurting the subject.

(2) Analysis technology for correlation between external stimuli, physiological responses and sensory factors

Correlation analysis technology to obtain significant statistical data on the correlation among external stimuli, physiological factors and the human senses.

(3) Stimulated environment presentation technology

Stimulated environment presentation technology which can efficiently generate and control heat, sound, light and other external stimuli that influence the human senses.



Medical and Welfare

The population ratio of the aged in Japan is increasing very rapidly that never happened in the world. In the coming aged-society, there will be changes in the condition of public life such as follows: change of disease variation, healthy awareness, demands of the healthy aged for a life worth living and living socially, needs of promotion of self-reliance of the disabled aged and handicapped person and reduce of loads of helpers for them.

To cope with the situation, it is strongly required that synthetic propulsion of research and development of medical and welfare technology and spread of the apparatus.

Research and Development Programs

Non-Invasive Continuous Blood Glucose Monitoring in System (1990-1993)

Purpose of Research and Development

The purpose of this project is to develop non-invasive continuous blood glucose monitoring in system to keep diabetic patients' blood glucose level at normal level.

Contents of Research and Development

In this project, instead of a blood sample, a suction effusion fluid, which is collected by a weak evacuation of the skin and contains the same glucose level as in blood, is used.

Optical Tomographic Imaging System (1992-1998)

Purpose of Research and Development

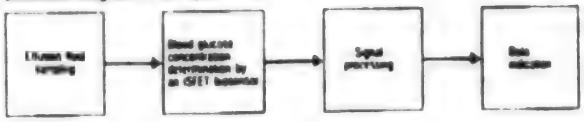
The purpose of this project is to develop diagnostic system which can obtain tomographic images of oxygen metabolism in living bodies by the CT (Computed Tomography) method using near infrared light.

Contents of Research and Development

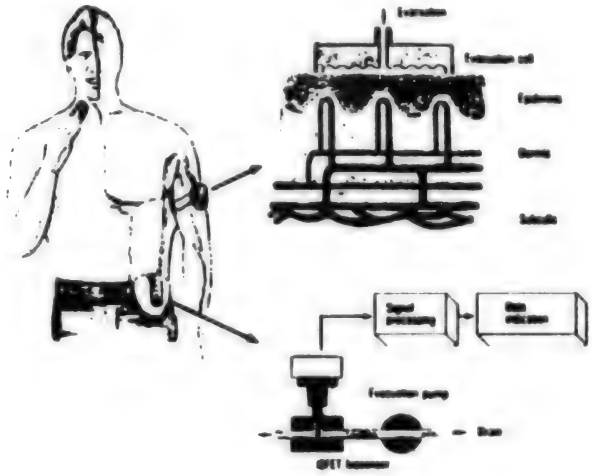
This project is to develop an optical tomographic imaging system which can obtain tomographic images of oxygen metabolism in living bodies by the CT method using near infrared light transmissible through living bodies and monitor patients non-invasively and continuously.

This system comprises near infrared pulsed light sources, light guides, an optical scanning unit, detectors, a data processor and an image processor.

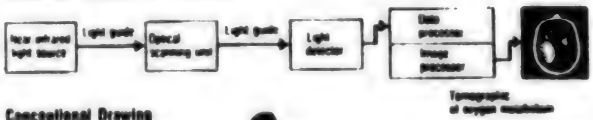
Schematic Diagram of the System



Conceptional Drawing of the Completed System



Schematic :diagram of the System



Conceptional Drawing of the Completed System

Stereotactic Treatment System for Cancer (1992-1995)

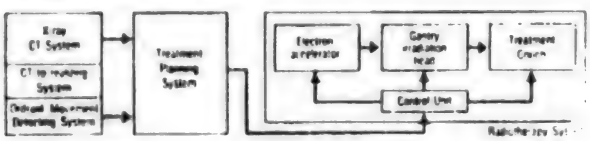
Purpose of Research and Development

The purpose of this project is to develop a treatment system for cancer, in which effective treatment is made successfully by applying high dose of X-ray irradiation to a lesion with almost no injury to normal tissue surrounding the lesion anywhere in the whole body.

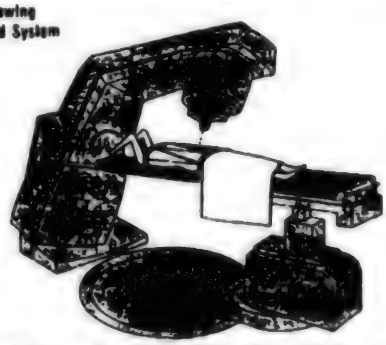
Contents of Research and Development

This project is to develop the stereotactic treatment system for cancer, which consists of the therapy planning system which calculates a location of the cancer lesion by X-ray CT or the like, the irradiation head which gives X-ray irradiation stereotactically and quantitatively to the lesion in accordance with the lesion displacement couch which executes position control so as to attain X-ray irradiation with respect to the shape of cancer lesion.

Schematic Diagram of the System



Conceptional Drawing of the Completed System



Digital Hearing Aids (1990-1994)

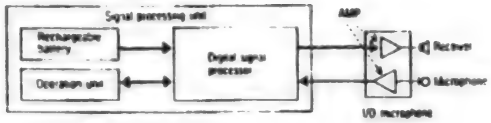
Purpose of Research and Development

The purpose of this project is to develop a hearing aid with improved speech intelligibility and comforting sound realized by digital signal processing because hearing aids conventionally available on the market are mostly analog type, with inherent drawbacks in speech intelligibility and comfort.

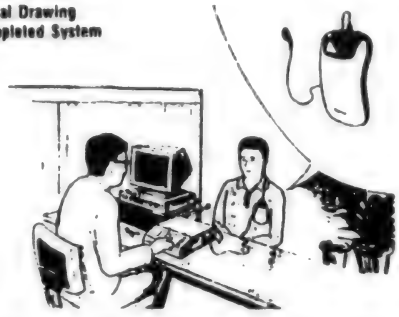
Contents of Research and Development

This project is to develop a new digital type hearing aid by developing new digital signal processing technology for improving the frequency and temporal resolution, and to develop new methods for noise reduction, fitting the hearing aid's characteristics, and hearing evaluation.

Schematic Diagram of the System



Conceptional Drawing of the Completed System



Ambulatory Apparatus With Weight Bearing Control (1991-1995)

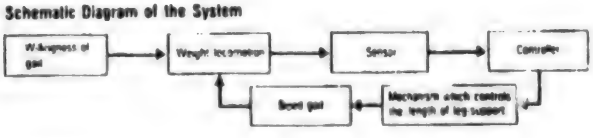
Purpose of Research and Development

The purpose of this project is to develop an apparatus which controls the length of the leg-support, and assists the handicapped with a gait disturbance to achieve ambulation by two legs for them.

Contents of Research and Development

This project aims to develop an apparatus which has the characteristics closely like that of the human gait by controlling the length of the leg support, and achieves level walking without a high consumption of human power.

Schematic Diagram of the System



Conceptional Drawing of the Completed System

Next-Generation Dental Product Engineering System (1993-1997)

Purpose of Research and Development

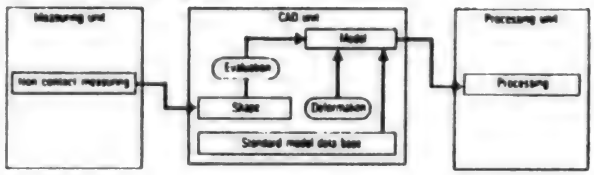
Depression of oral functions in the aged in Japan has become a serious problem with the increase in the aging population. The depression—the decrease in oral function such as mastication, conversation and aesthetic aspects—is caused by the falling out of permanent teeth.

Therefore, this project is to develop a total system for diagnosing, designing and producing oral devices that best fit to patients.

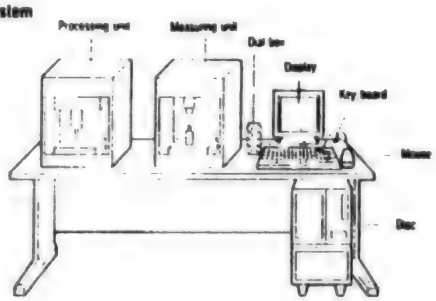
Contents of Research and Development

This project is to develop a total system—computer aided prosthetic system—for diagnosing, designing and producing dental product which best fit to patients, based on morphological 3 dimensional information of the oral cavity by optical measuring system.

System Diagram CAP System



CAP System



Evacuation Care System (1989-1993)

Purpose of Research and Development

The purpose of this project is to develop a system to remove the solidified feces stagnating in the rectum by suction with crushing and softening by an ultrasonic system, in order to solve the problem for the evacuating difficulty come by bedridden aged people and patients with neuroparalysis.

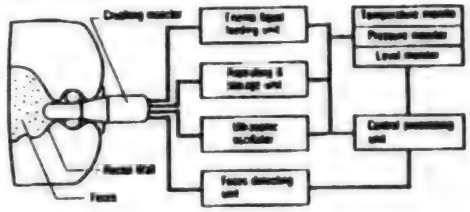
Contents of Research and Development

In this project, an evacuating system will be developed for removing the solidified feces stagnating in the rectum with suction, which are crushed and softened

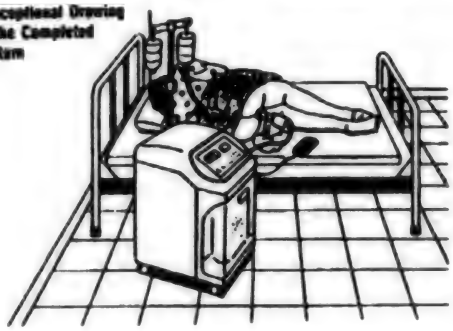
by using an ultrasonic system with a rectal washing unit, without leaking out the bad odor outside.

This system is composed of an ultrasonic oscillating and vibrating unit, a rectal washing and a safety-system, thereby, evacuating treatment can be safely and exactly operated within a short time, and also, physical and mental pain and burdens can be reduced for both patients and caretakers, as features of this system.

Schematic Diagram of the System



Conceptional Drawing of the Completed System



Therapeutic Training System for Preventing the Incontinence of Urine (1991-1994)

Purpose of Research and Development

The purpose of this project is to develop therapeutic training system for preventing the incontinence of urine by measuring methods of the urine without directly contacting internal organs and using bio-feedback system, in order to free patients from the use of diapers and let them join in social activities more positively.

Contents of Research and Development

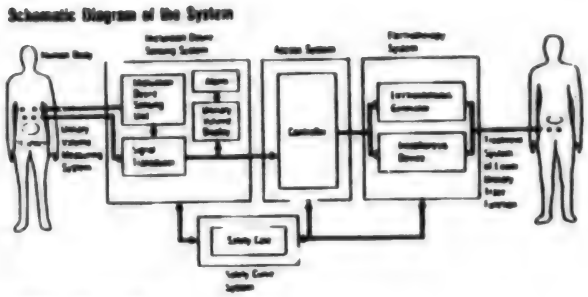
In this project, following total system will be developed for the prevention of the incontinence of urine and enabling its sufferers to enjoy their daily lives activity. The total system consists of:

1) measuring methods of the urine amount in the bladder of a patient without directly contacting internal organs,

2) controlling methods for both contraction or loosening of patient's diuretic stimulation or iontophoresis,

3) a compact light-weight bio-feedback system.

Schematic Diagram of the System



Conceptional Drawing of the Completed System

System for Supporting Independent Evacuation (1993-1998)

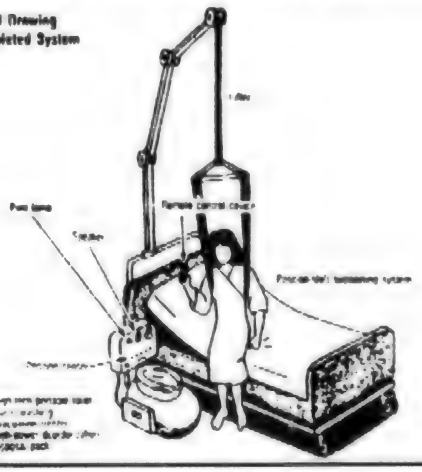
Purpose of Research and Development

System for supporting independent evacuation by using a bedside portable toilet with a warm water washer, a preservation freezer of feces, a strong odor absorber and an easy processing mechanism as well as a lifter that supports the transfer from bed to toilet will be developed for prevailing to be bedridden and for reducing the loads of caretakers.

Contents for Research and Development

A system being developed in this project consists of a lightweight low-cost bed that enables the transformation of body posture from lying to sitting positions in order to move from bed to toilet, a lifter that reduces the weight loaded to the leg or pelvis and facilitates the move from bed to toilet, a portable toilet that can be used in rooms and has functions of warm-water washing, strong odor absorbing and preservation freezer, and a device for processing feces consisting of an easy packing container that can be disposed in a toilet to process the feces cleanly.

Conceptional Drawing of the Completed System



Three-Dimensional Information Display Unit for the Blind (1989-1993)

Purpose of Research and Development

The purpose of this project is to develop an information display unit using vertically moving pins to present three-dimensional information in order to recognize three-dimensional information for many visual handicapped people.

Contents of Research and Development

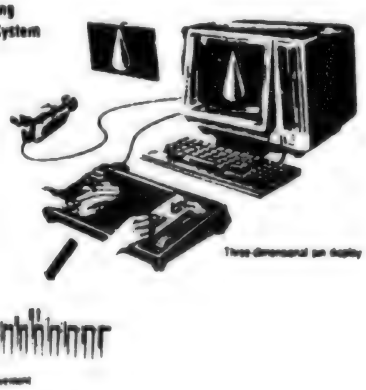
This project is to develop a three-dimensional information display unit which uses pins arranged on a plane to represent information on computer display images. Information on the display is transmitted to the pin unit and is converted to vertical movement of individual pins. A blind operator touches the artificial three-dimensional pin display and recognizes information.

Out test unit consists of an image input device, a computer system, and a three-dimensional information. The computer system processes image data and edits input information. It then rewrites it in algorithm form to enable the blind to easily recognize the resulting three-dimensional output.

The three-dimensional pin display has a 64 x 64 arrangement (4,096 pins in total). The processed images information from the computer system is displayed as artificial three-dimensional information by the vertical movement of individual pins, which are controlled with individual pin actuators.

Schematic Diagram of the System

Conceptional Drawing of the Completed System



Comprehensive System for Supporting Wheelchairs (1993-1998)

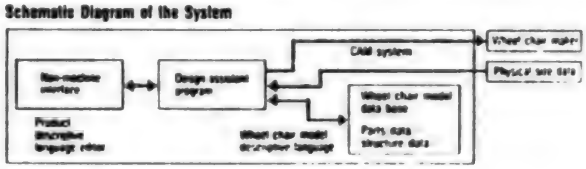
Purpose of Research and Development

A design and manufacturing support system to improve the adaptability of wheelchairs to the users and a low-cost and small-size transportation support system used in public space will be developed.

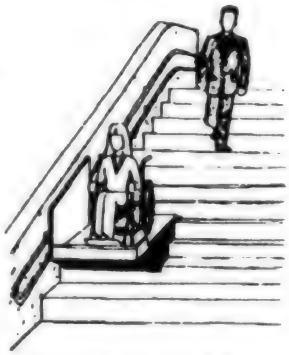
Contents of Research and Development

In this project a design and manufacturing support system as well as a transportation support system will be developed. By designating the characteristics and the dimension of a wheelchair user the first system supports a design of wheelchairs best fit to a user and provides with data necessary to produce wheelchairs. The second system includes a low-cost and small-size staircase lifter that can be set up in a public space with a minimal amount of construction work.

Schematic Diagram of the System



Conceptional Drawing of the Completed System



Survey on International R&D Cooperation in the Field of Medical and Welfare Equipment (1992-)

Purpose

Requirement for the development of medical and welfare devices is getting stronger because of the increase of adults' diseases such as cardiac disorders and of the increase of patients needing daily care as a result of a progress of aging. These problems are common in advanced countries. On the other hand, in the developing countries the structure of the diseases and the environment for using medical equipment is greatly different from that of the advanced countries. Medical equipment developed in the advanced countries therefore cannot perform their full functions and consequently technologies to adapt medical equipment to the use in developing countries is required to be developed.

Taking into these circumstances the environment and conditions will be surveyed to conduct an international R&D cooperation in the field of medical and welfare apparatus.

Description

In 1993 FY possible R&D theme will be selected and its detailed plan will be established to carry out the actual R&D in the future.

Fundamental Research on Medical Welfare Equipment Technologies (1993-)

Purpose of Research

In a development of policy for research on welfare apparatus technologies, it is important that the technologies correspond with an advanced age society in geometrical progression.

Therefore, fundamental research on medical welfare equipment technologies are enforced for the purpose of strengthening study on medical welfare equipment technologies that related to variety of research fields and of extending research field on equipment technologies.

Contents of Research

The following research is started in fiscal 1993.

1. Fundamental research on sensory substitution feedback systems for motor function training.
2. Fundamental research on human interface technology on outdoor activity of senior and handicapped.
3. Fundamental research on the analysis of nerve fiber regeneration process.
4. Fundamental research acquisition of visual information for the blind.

Project for the Collection, Analysis and Distribution of Information on Medical Welfare Equipment (1993-)

1. Research Study for Technology Transfer to Welfare Apparatus Purpose

The aim is to excavate technology seeds and to adapt the seeds to user's needs by seizing industrial technologies which are applicable to medical welfare equipment.

Contents

Suggestion of research themes for engineers which are based on user's needs, seizing new technologies applicable to medical welfare equipment and presentation for engineers, adaptation of technological seeds to user's needs and presentation of the apparatus image for users and consideration of the apparatus image by users and improvement.

2. Data Base Construction

Purpose

Make a data base of sensational character such as vision, hearing and physical strength of the aged and handicapped person for "high-tech" comfortable and satisfied medical welfare equipment.

Contents

Accumulation of sensational character and physical data of the aged and handicapped person which are necessary for R&D of medical welfare equipment and to make a data base of that for easy use for designing and development of the equipment. Making data base of technological seeds.

Project for Promoting the Development of Practical Medical Welfare Equipment (1993-)

Purpose

It is normally difficult for a private enterprise alone to commercialize new technologies that is applicable to medical welfare equipment, because the marketing and development risk is generally high about medical welfare equipment.

Description

This project financially supports the development of medical welfare equipment that is based on new technologies developed under the national R&D programs for medical and welfare equipment as well as under independent R&D by national research laboratories or private enterprises.

Leading Research (SENDO KENKYU)

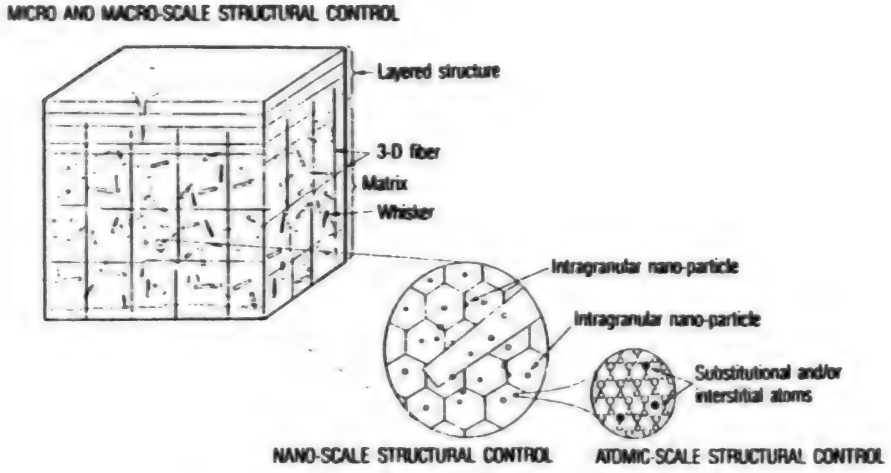
—Purpose

AIST focuses on the following R&D areas of the industrial science and technology.

(1) The fundamental and creative R&D which will contribute to a further development of the economy and society.

(2) The mission oriented R&D to attain the social goal.

In the fields mentioned above, especially in the fields of fundamental and creative R&D, most subjects are difficult to undertake as R&D projects immediately because of the technological uncertainty though the possibilities of promoting such projects in the future can not be rejected. In order to promote the R&D effectively and systematically, the Leading Research (SENDO KENKYU ... in Japanese) Scheme aims to cope with this type of R&D and evaluate before it is led to the stage of R&D project.



Representative Structure of Integrated Advanced Materials

—Themes

Themes selected for the Scheme may be ones which are difficult to undertake as projects in short time owing to the reason as follows:

(1) Additional studies are necessary because of the technological uncertainty.

(2) Objective must be narrowed in order to start project style R&D.

(3) Pre-project investigation on the possibility and/or scheme for international collaboration.

(4) It's necessary to consider in various aspects because of complicated and deep relation to the social system.

—Procedure

R&D on the above themes will generally be implemented in the following way:

(1) R&D will be conducted primarily by the laboratories belonging to the AIST, and when necessary, universities and private firms.

(2) The average period for 2-3 years. (It may extend up to a maximum of 5 years.)

Inorganic Fusion Materials With Higher Older tStructure (1993-)

Purpose of Research and Development

To develop new concepts for simultaneous structural control of inorganic bulk materials at each and every scale (i.e., *structural integration*), from the atomic and molecular to the macro-scale, and concurrently, finding and formulating new seeds for materials processing. To examine the feasibility for creation of inorganic materials which integrate diverse functions (mechanical, electrical, chemical).

Contents of Research and Development

(1) Basic process technology for integration

Technologies, based on known phenomena such as solid solution and precipitation, for controlling internal interfaces in heterogeneous structure (e.g., interfaces between grains with different size and scale), allowing simultaneous control of orientation and arrangement of grains at each and every scale.

(2) Basic technology for integrating functional elements

Technologies allowing incorporation of nano-scale functional elements, with simultaneous control of structures at the micro and/or macro-scale.

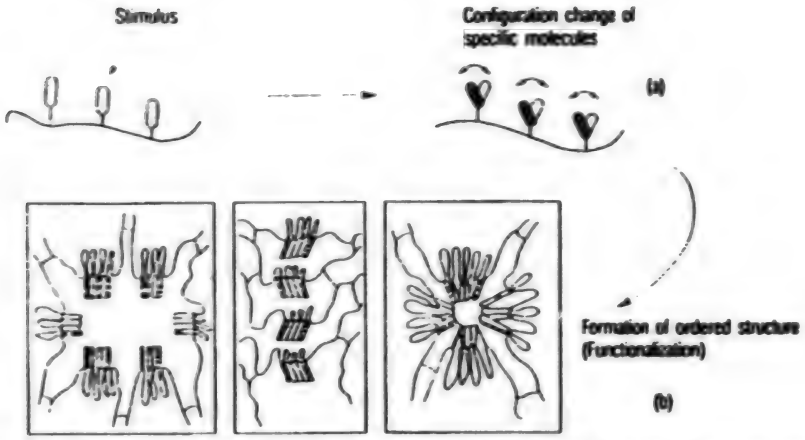
(3) Basic technology for analysis and evaluation

Technologies aimed to identify and evaluate controlling key factors to integrated materials, that eventually lead to structural optimization. Analysis and evalution of properties of the developed materials.

Autonomous Reaction Materials (1993-)

Purpose of Research and Development

Research on the synthesis and development of autonomous polymeric materials that change their molecular structure and/or aggregation state responding to stimuli such as light, temperature, electricity, and chemical substances is made. Through clarifying co-relationship among stimulus-structure-movement and creating a function of reacting to multiple stimuli, autonomous reaction materials which realize movement and functions of high levels under a wide variety of stimuli and conditions are developed.



The configuration change of specific molecules is induced by stimuli such as light, heat, electric field, pH etc. (a), and leads to the formation of ordered structure (b). The shape and/or property of the polymeric material changes depending on the stimuli.

Contents of Research and Development

(1) Design and synthesis of autonomous materials

Search for materials which change their structure and/or aggregation state from biopolymers and synthesized polymers is made.

(2) Search for the synthesis of fixed materials

Materials fixation technology which makes highly efficient and reliable response is developed.

(3) Clarification of mechanism and function assessment

Assessments of stimuli reacting materials and fixed materials as well as elucidation of stimuli reacting mechanism are made.

Jungle Biotechnology (Technology for Preservation and Utilization of Functions of Tropical Organisms) (1993-)

Purpose of Research and Development

In tropical areas there is wide variety of biological species with unknown useful functions. These species are considered to be valuable resources. Basic researches will be carried out to conserve biological diversity in tropical area and also to utilize biological functions.

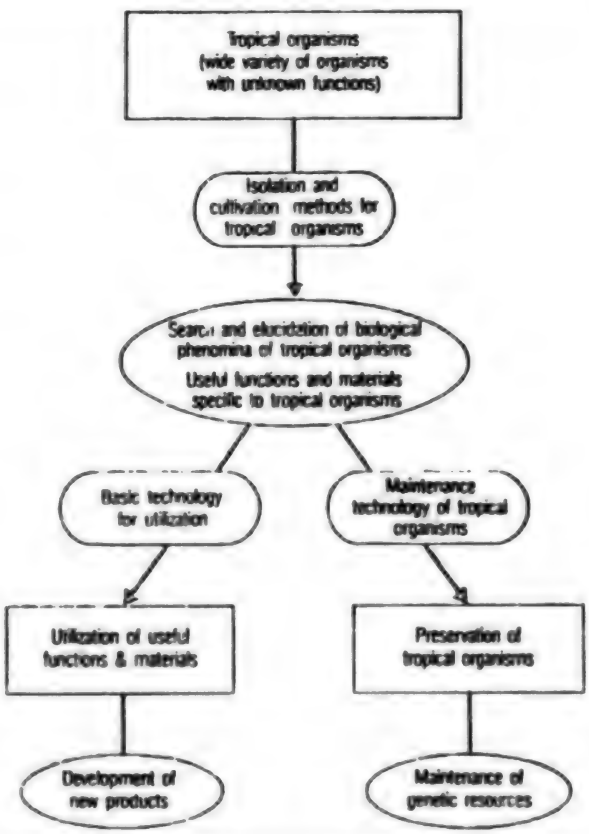
Contents of Research and Development

(1) Survey on the present status of conservation of organisms with useful functions

(2) New methods of isolation, cultivation, classification and conservation for ex-situ conservation of tropical organisms

(3) Screening systems for useful functions of tropical organisms

(4) Survey for making joint research groups among Japan, USA, and Europe to promote global cooperation



Femtosecond Technology (1993-)

Purpose of Research and Development

The word "Femtosecond (10^{-15}[sec]) Technology" is a coinage that denotes research activities concerning ultrafast phenomena around 100 femtoseconds or shorter. It includes but is not limited to electrooptic sampling,

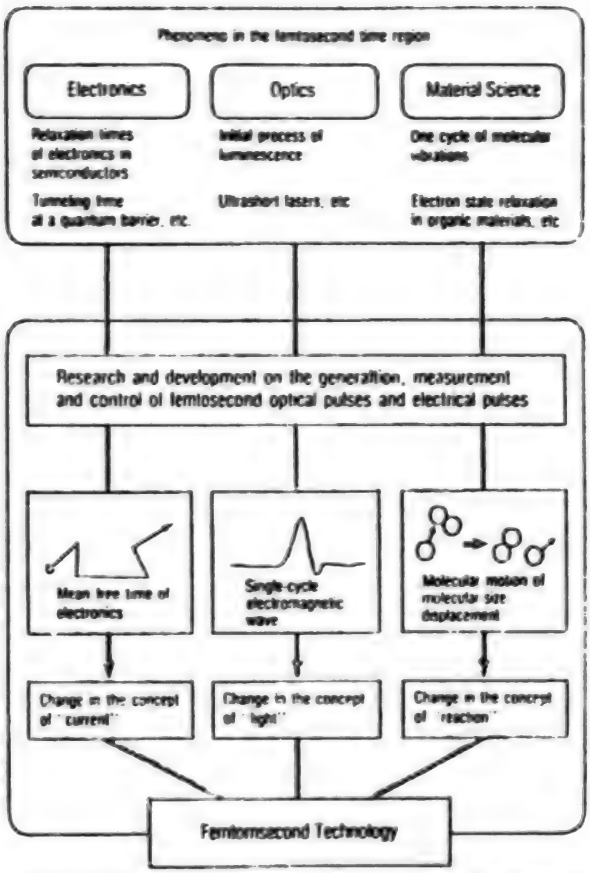
soliton transmission, and several other femtosecond-regime electronics and optics. There are significant technology gaps between picosecond technologies and femtosecond technologies for many technology fields including electronics and optics. It is expected that the femtosecond technology will contribute to the future information society as one of infrastructures.

Contents of Research and Development

(1) Research on physics of femtosecond phenomena

(2) Research on manipulation of femtosecond phenomena

(3) Research on the basic technologies for the transmission and control of femtosecond pulses



Ecofactory (1993-)

Purpose of Research and Development

To establish technologies for achieving harmony with the global ecological system through the establishment of Ecofactory technology, leading and basic research for the production system technology, restoration system technology and system technology are advanced.

Contents of Research and Development

(1) Global concurrent design technology

The development of products design and process design technologies for concurrently minimizing the burden on the ecological system through the entire life cycle of the products.

(2) Waste reduction machining technology

The establishment of technologies for machining and assembling products of easily disassembled structures as well as advanced materials of excellent recyclability.

(3) Technology for automatic disassembling robot system

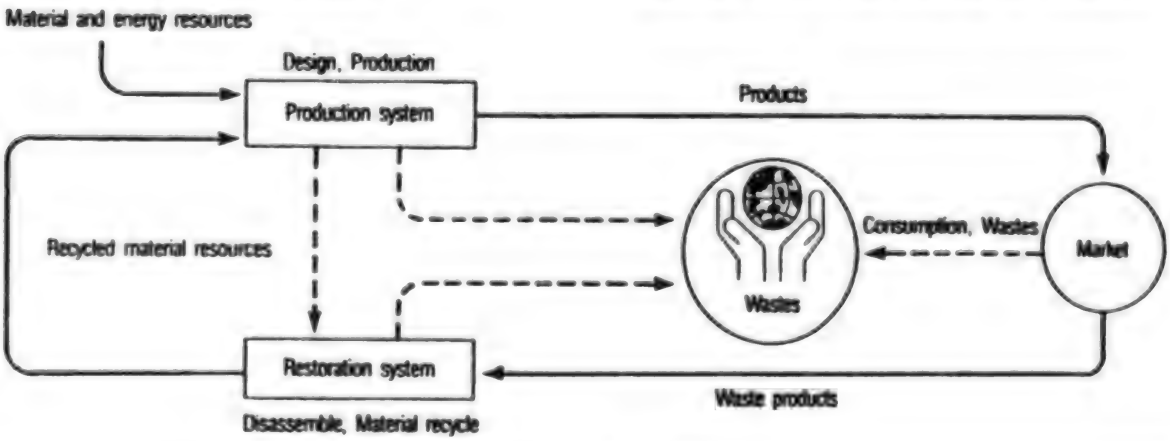
Disassembling robots (dismantling robots) are to be developed to increase the recycling ratios of machined and assembled products.

(4) High-quality materials recycling technology with high-efficiency

The development of a technology enabling the high quality recycling of recovered materials.

(5) Ecofactory systems technology

The development of systems technologies for designing, assessing and operating the Ecofactory.



III. Completed Projects

(Unit: million yen)

	Project Name	Period	Total Expenditure	Outline of Project	R&D Results
New Materials	Advanced Alloys with Controlled Crystalline	1981 – 1988	about 3,900	Development of heat resistant alloys which have high toughness with single crystallization, grain refinement and uniform distribution of hard particles.	Experimental turbine blades and turbine disks for a jet engine were successfully produced by developing various types of advanced alloys with world's greatest strength and by establishing technologies for manufacturing products of complicated shapes from those alloys.
	Advanced Composite Materials	1981 – 1988	about 4,649	Development of advanced composite materials which are lighter than aluminum alloys and stronger than steels in strength, stiffness, etc., in response to specific application. They are used as structural materials with high reliability.	A carbon fiber reinforced composite material which uses high performance resin as material was developed. This developed material surpasses conventional aluminum alloy, a typical light-weight material, in specific strength by twice or more and in heat resistance by 150 degree or more. Also, lightweight aluminum alloy composite materials reinforced by carbon fiber and by silicone carbide fiber were developed.
	Synthetic Membranes for New Separation Technology	1981 – 1990	about 4,179	Development of synthetic membranes which can separate and purify mixed gases or liquid mixtures by utilizing differences in the property of substances.	Separation membranes for production of absolute ethanol, concentration of organic compounds in water, resolution of racemic amino acids, and separation of carbon monoxide or oxygen from mixture with nitrogen have been established.
	Synthetic Metals	1981 – 1990	about 2,883	Development of polymer materials which exhibit electric conductivity like metals together with polymers' intrinsic properties such as light weight, resistance to corrosion and good processability.	World highest conductive polymers such as polyacetylene (4×10^3 S/cm), poly-p-phenylenevinylene (2.7×10^3S/cm), polypyrrole (3×10^3S/cm) and graphite (9×10^3s/cm) have been developed.
	High-Performance Plastics	1981 – 1990	about 2,441	Development of high performance plastics which are light in weight but as strong as metal possibly used as structural materials.	Polymer materials having superior modules of elasticity, such as laminated liquid crystalline polyallylate (113GPa), poly-p-phenylenebenzobisthiazole/ aramid molecular composite (110GPa), three dimensional network of polyacrylate/metal (84GPa) and diacetylene compounds (25GPa), etc., have been developed.
	High-Performance Ceramics	1981 – 1992	about 11,262	Development of high-strength ceramics at extremely high temperature to be used as materials for gas turbine components.	Si_3N_4 and SiC ceramics with high reliability which can stand high temperature (~ 1200°C) were developed as materials for gas turbine components.
	Photo-Reactive Materials	1985 – 1992	about 1,999	Development of photoreactive materials, which characteristically exhibit a reversible change in the structure or arrangement of molecules in response to light stimulus.	Photochromic LB films for multiplex recording and photochemical hole burning materials which work at liquid N_2 temperature have been developed.
Biotechnology	New Method of Producing Olefins	1967 – 1972	about 1,200	Economic production of olefines by direct cracking of crude oil.	It was proved that thermal cracking method is a promissing method from the data of test plants which processed 5 tons of crude oil per day.
	Olefins Production from Heavy Oil as Raw Material	1975 – 1981	about 13,800	Technology for producing olefines from high sulphur-content heavy oil fraction.	A large pilot plant was constructed which can processed 120 tons of crude oil per day. The plant ran for 1000 hours continuously.
	C1 Chemical Technology	1980 – 1986	about 10,500	R&D on a technology for the economic production of basic chemicals from C1 compounds.	Technology for producing gas was established which is based on membrane separation methods to isolate synthetic gas from coal and natural gas.
	Bioreactor	1981 – 1988	about 2,978	Technology for industrial utilization of very efficient biological reaction.	Bioreactor systems that achieve reactions for producing hydroquinone from phenol, acetic acid from carbonic acids gas and muconic acid from benzoic were developed.
	Large-Scale Cell Cultivation	1981 – 1989	about 3,362	Technology for efficient cultivation without the need of expensive natural culture media.	A new record in dense cultivation, 2×10^8 cells/ml, has been achieved on highly versatile non-serum culture medium. This can replace the more costly conventional natural culture fluid.
	Utilization of Recombinant DNA	1981 – 1990	about 3,084	Technology to make new microorganisms which can be used in the production process by means of recombinant DNA.	A fused enzyme which genetically combines the esterase and reductase in a cell membrane was successfully constructed. The steroid hormone can be efficiently produced.
	New Water Treatment System	1985 – 1990	about 9,800	R&D on a new wastewater treatment system using a high-concentration bioreactor and separation membrane for water reuse and energy recovery.	A bioreactor which can produce methane efficiently in high density of microorganisms, and membrane module which can enhance methanol fermentation were constructed.

	Project Name	Period	Total Expenditure	Outline of Project	R&D Results
Electronics, Information and Communication	Super-High Performance Electronic Computer	1966 – 1971	about 10,100	R&D on large scale computer system with super-high performance toward the LSI generation from the IC generation.	Not only the computer hardware itself but also software, input/output units, and semiconductor devices for utilizing the computer efficiently have been developed.
	Pattern Information Processing System	1971 – 1980	about 21,900	R&D on computer technology for recognition and processing of pattern information such as characters, pictures, objects, and speeches, which have been difficult to be dealt with by computer.	Input devices and apparatuses for pattern information processing, and software for pattern recognition have been developed. By using these results of R&D, optical character readers and image processing systems have been put to practical use.
	Optical Measurement and Control System	1979 – 1985	about 15,700	R&D on an opto-electronic system of precise measurement and control handling massive volume of data including picture image under adverse environments such as in a plant where electromagnetic induction or a corrosive gas etc. exists.	Prototype system for oil refining plants have been constructed and the elemental technologies have been established, which are utilized for measurement and control in various kinds of plants with sufficient safety and reliability.
	Fortified ICs for Extreme Conditions	1981 – 1985	about 1,315	R&D on fortified ICs which can withstand any external conditions such as high energy irradiation, high temperature and mechanical vibrations and shocks. They are necessary to construct electronics systems which reliably operate under hazardous environments such as space, nuclear reator and vehicle.	Silicon-based ICs and compound-based ICs have been developed which operate reliably under strenuous environmental conditions: radiation 10^8rad, temperature 225°C, vibration 40G, impact 5,000G.
	High-Speed Computing System for Scientific and Technological Uses	1981 – 1989	about 17,500	R&D of a high speed computing system for processing enormous amount of data in a practically short time. For this purpose, high-speed devices, architecture and software for parallel processing have been developed.	Josephson junction devices and GaAs devices have been developed. High-speed parallel processors for distributed processing and memory units of large capacity and high-speed have been put to practical use, which have contributed to progress in fields of processing of satellite image data, meterological forecasting, sophisticated simulation, etc.
	Superlattice Devices	1981 – 1990	about 3,666	Development of semiconductor devices which utilize various electronic phenomena appearing in semiconductor hetero-structures with monolayer accuracy.	Resonant hot electron transistors (RHET) were fabricated, which showed high speed, high gain performance. Fabrication of majority logic circuits and full adder circuits by RHETs only a quater of the number of the conventional transistors proved that high-density integration is possible. Further, development of double hetero-growth method made it possible to embed micro-electrodes structure in a crystal, proving the feasibility of a permeable base transistor (PBT).
	Three-Dimensional ICs	1981 – 1990	about 6,488	Development of three-dimensional ICs which consist of several device layers stacked and isolated from each other by insulating layers.	An semiconductor-on-insulator technology and SOR lithography technology were developed. An prototype high-density integrated device with an integration level of 12K devices/mm^2 and six active layers was fabricated. Further, a prototype three dimensional circuit capable of parallel processing with logical decision capability was fabricated to prove that image processing at a high speed (a few msec/frame) was possible.
	Interoperable Database System	1985 – 1991	about 7,600	R&D on technology for cooperative operation of computers of different brands and constructing reliable multi-media database systems on computer networks as fundamental technologies for sophisticated information-oriented community	Communication protocols in conformity to Open System Interconnection (OSI) of the international standard organization (ISO) have been developed, and incorporated to the Japan Industry Standards (JIS). The results were utilized for system configuration in municipalities and private sectors.
Machinery and Aerospace	Direct Steelmaking Process Using High Temperature Reducing Gas	1973 – 1980	about 13,700	R&D on direct steelmaking technology aimed at a closed system which uses the heat energy from multi-purposes high-temperature gas-cooled reactor in the steelmaking process for the solution of pollution by steelmaking process and getting rid of dependence on coking coal.	High-temperature heat exchanger which transferred the heat of 1,000°C primary helium to secondary helium, super heat resistant alloy which bore the long time usage at 1,000°C, high temperature heat insulator, and reducing gas production machine which produced low cost reducing gas from decompression louling oil were developed. Technologies necessary to direct steelmaking pilot plant which would connect to 50MW (thermal output) class multi-purpose high-temperature gas-cooled experimental reactor were established.
	Jet Engines for Aircraft	71 – 75 1st phase 76 – 81 2nd phase	about 6,900 about 12,900	Research and development work on a fan jet engine for civil transport with high efficiency low noise and low emission was carried out. Basic engineering technology was developed in the 1st item. Further, stability, durability, reliability, etc were established and a fan jet engine of thrust class 50 ton was developed in the 2nd term.	The project contributed a lot to the improvement of the jet engine technology in Japan. The developed FJR engines were installed in the experimental STOL (Short distance Take Off and Landing) aircraft. Further it led to the beginning of international cooperative development of the turbofan engine V2500.
	Flexible Manufacturing System Complex Provided with Laser	1977 – 1984	about 13,500	R&D on new automatic production systems integrated from the material fabrication to product inspection, which were flexible and provided quick through-put in the manufacture of small batches of machine components with the application of the laser on the metalworking process.	The experiment plant was constructed in Mechanical Engineering Laboratory, and research of total operation was carried out. Oscillation of world largest class commercial high power CO_2 laser was succeeded in.
	Observation System for Earth Resources Satellite-1	1984 – 1988	about 10,900	Research and development work on the observation system, which was carried on Japanese Earth Resources Satellite-1 (JERS-1) launched in February, 1992, was conducted.	The design and manufacturing technology for the observation system, which enables the effective and economical acquisition of data on the world's natural resources from space, was established.
	Automated Sewing System	1982 – 1990	about 8,200	R&D on an automated industrial sewing system that would allow small-lot, wide variety production in a flexible and reasonable way to cope with rapid changes in the domestic apparel market.	After R&D of essential technology was under taken to develop main technologies and machines which constituted automated sewing system, a test plant of ladies's blazers was constructed in Tsukuba Center Inc., and research on its systematization was under taken. And availability of the plant was inspected. Then technical data which was necessary for practical system was obtained and operation method was mastered.

	Project Name	Period	Total Expenditure	Outline of Project	R&D Results
Machinery and Aerospace	Advanced Robot Technology	1983 – 1990	about 15,500	R&D on advanced robot technology and basic technologies for systems to support people working under difficult or dangerous conditions.	As elementary technologies, the actuator providing 10 times improved power per weight from the conventional one, high density tactile sensor for the fingertip of the robot hand, compact fiber optic gyroscope for the navigation of the mobile robot and the transpiration cooling method to maintain the availability of the robot in high temperature circumstance were developed. With the employment of these developed devices, the tele-operated robot for the inspection and maintenance of nuclear power plants, subsea robot for the maintenance, inspection and repair of ocean exploitation and so on were manufactured. Furthermore, the technical feasibility of the developed robots was successfully evaluated.
Natural Resources	Desulfurization Process	1966 – 1971	about 2,700	R&D on the stack gas desulfurization technology for removing SO_2 gas from after-combustion gas emissions, and on the direct heavy oil desulfurization technology for removing sulfur content directly from heavy oils Backgrounds; As heavy oil consumption increased, the sulfur content in the heavy oils came to be released as an SO_2 gas into atmosphere, and thus many social problems were occurred.	Not only the desulfurization technology was being put into use at large-scale thermal power plants, but also did the Government take the initiative in developing the technology when environmental pollution began receiving social attention. These have significantly advanced subsequent development of raw desulfurization technology and, installation of desulfurization equipment, by private companies.
	Remote Controlled Undersea Oil Drilling Rig	1970 – 1975	about 4,500	R&D on completely new types of oil drilling equipment capable of operating in deep oceans. Background; There was a tendency for oil drilling sites to progress from land through seashores to continetal shelves.	The mechanism of the equipment was developed exactly as initially planned, and the results were also taken over by the "Subsea oil production system" project. Also, the corresponding technology was effectively used as a technological basis.
	Resource Recovery Technology	73 – 75 1st phase 76 – 82 2nd phase	about 1,300 about 11,300	R&D on the new processing systems intended for effective use of resources and smooth disposal of solid urban waste, not by dumping into reclaimed land or incineration, from the viewpoint of resources and energy saving and the solving of problems associated with waste disposal	These systems are already put into practical use in the local cities and towns of Hokkaido and Nagano, Kouchi, Ehime, and Ohita prefectures, and selective crushing/classifying equipment for waste has been licensed to Australia. Thus, the systems are significantly contributing to more advanced processing of waste for effective utilization as resources.
	Subsea Oil Production System	1978 – 1984	about 18,200	R&D on an efficient system for subsea oil production applicable to the continental shelf and slope surrounding Japan and to deep sea oil fileds.	This system with sufficient safety, reliability, durability, and economy, enables future development of oil fields in deep waters while at the same time contributing to the creation of new expansions in the development of oil fields in relatively shallow waters.
Human, Life, Living and Society	Sea Water Desalination and By-Product Recovery	1969 – 1977	about 6,700	Under the background of deficient rain becoming big problems in the large cities including the Metropolitan area, seawater desalting technology was developed with collecting the extract such as salt and potassium chloride.	Among many technologies of desalting seawater, the one applied in this project is the multi-stage flash distillation method and can produce much water compared with others. Research was carried with trial plant (it produces 3,000m^3/day) and partly manufactured large-scale plant (it produces 100,000m^3/day)
	Electric Car	1971 – 1977	about 5,700	Public pollutions by automobile such as air pollution by exhaustive gas and noise pollution become big problems as the cities become large. To stop these public pollutions, development of electric vehicle system was carried out, because it exhausts no gas, reduces noise and is easy to switch over to control automation.	Two types of world-leading vehicles were developed a battery-driven vehicle which can run 250km (former 100km) by a single recharge and battery-and-engine driven vehicle which can run about 450km
	Comprehensive Automobile Control Technology	1973 – 1979	about 7,300	As the number of automobiles increases in Japan, many problems have emerged such as traffic accident, traffic jam and air pollution. For solving these problems, a direct traffic control system was developed with which necessary information to individual vehicle vehicle can be sent directly to it.	This system consisted of five subsystems which include path guidance, information for running, emergency information, flexible information display and precedence of public vehicle. Prototype system was operated in the testing area (about 30km^2) in Tokyo
Medical and Welfare	Medical Apparatus: Multichannel Automatic Biochemical Analyzer	1976 – 1978	about 300	In the program, a less expensive, highly efficient multi channel automated biochemical analyzers has been developed.	The analyzer is capable of testing 300 samples per hour in blood biochemical tests, with 30 tests analyzed simulated.
	Medical Apparatus: Automated Differential Blood-cell Analyzer	1976 – 1978	about 300	This analyzer utilizes pattern recognition technology using a microcomputer and performs the differential count automatically.	The device is capable of differentialing six types of normal leucocytes same as a technologist but with high through put.
	Medical Apparatus: Artifical Heart for Clinical Use	1976 – 1979	about 500	The assist heart device was developed for clinical use under this program.	The bladder of a blood pump is fabricated with Lycra (Polyether type polyurethane) and H-USD (Heparinized polyurethane)
	Medical Apparatus: Home Dyalysis Device Portable Artificial Kidney	1976 – 1979	about 600	The program, aimed at the development of equipment with which a patient can treat himself easily and safely at home, at office or on a trip, and one which can be attached to a patient.	There are two types available. Model 1 is a combination of a small-sized, high-efficient dializer and an absorber. It is a dialysate pump, and a hybridized detection controlled with micro computer, is easy to use, safe and portable. Model 2 is a combination of a small, highly efficient ultrafilter and an absorber. It is a Model 1 without dialysate pump and more compact than Model 1.
	Medical Apparatus: Laser Scalpel	1978 – 1981	about 500	This development program, to promote the wide use of laser scalpels at general hospitals, aims at developing safer, easier touse, more stable, smaller, lighter, and less expensive equipment.	Two types of laser scalpel have been developed CO^2 laser scalpel with ben-dable light conduit and a YAG laser scalpel with optical fiber endoscope

		Project Name	Period	Total Expenditure	Outline of Project	R&D Results
Medical and Welfare		Position Computed Tomography	1979 – 1982	about 500	The equipment under development transmits nuclides that emit positrons (electrons having positive electricity) to the subject. An array of detectors detect gamma rays which are generated when these position are extinct, and to mograms or internal organs are obtained by computer processing of the collected data.	While theX-ray computed tomography, which has been already developed presents anatomic data, the positron on computed tomography will display the distribution of RI in the body as three-dimensional distribution in a quantitative manner. Thus, it will be able to detect a variety of metabolic processes.
		Liver Function Support Device	1979 – 1984	about 700	The equipment supplement the patient's liver functions and aid recovery.	This new equipment, while monitoring the conditions of the patient using a measurement and surveillance device for vital indicators, removes foreign substance in blood quickly with a detoxification device.
		Supporting System for Early Detection and Treatment of Neurological and Psychological Disorders	1981 – 1986	about 600	A system for assisting early detection and identifying the pathogenesis of neurological disorders of children computer assisted polysomnography. A system for facilitating drug therapy for neurological disorders.	The new device facilitates and expedites polysomnography. New apparatus supplies more accurate results within a minimum time and with minimum blood sample.
	Medical Apparatus	Blood Treatment System for Immuno-related Diseases	1983 – 1987	about 400	The system to treat immuno-related diseases by selectively removing harmful substances from the patient's blood using specific absorbents.	The whole blood or plasma is perfused through an adsorption column and the harmful substances are removed selectively through specific interaction with reagent.
		Photochemical Reaction System for Diagnosis and Therapy of Cancer	1984 – 1987	about 300	The instrument for diagnosing and treatment of cancer by applying photochemical reaction combined with laser and the cancer affinity substitutes.	This laser methodology has succeeded to solve some of the major problems inherent of previous therapuitic systems which used laser light heat energy.
		Immunological Cancer Diagnosis System	1985 – 1988	about 300	Development of high-performance reagents and a diagnosis system capable of measuring the slightest change in the concentration of tumor markers from the normal values, and correctly diagnosing of deep-part cancers like those in liver or pancreas.	Reaction efficeincy can be enhanced without requiring separation process. Even a trace amount of tumor markers can be measured at a high sensitivity within a short period of time. A highly accurate measurement can be expected by combining fluorescent labels and highly specific antibodies.
		Hyperthermia System for Cancer Therapy	1986 – 1989	about 400	Development of a new generation hyperthermia system. This consists of an heat-control unit, an ultrasonic temperature measurement unit and a treatment planning support system.	This makes it possible to selectively heat tumor tissues at a constant temperature tissues at a constant temperature in the range of 42 – 45°C, and to measure the temperature distribution of the heating area noninvasibly.
		Automatic HLA Typing System	1987 – 1990	about 300	A system to isolate lymphosyte effectively from blood, to fractionalize, measure and analyze the output date of specific bindings a particular lymphocyteantigen and dozens of anti-HLA antibody by specific marker.	This makes it possible to type of large number so HLAs simultaneously at high speed.
		Laser Angioplasty System	1988 – 1991	about 600	The laser angioplasty treatment system with which flexible fiber is inserted into a blood vessel and the lesion is observed and diagnosed for treatment.	Removal of occluded plaque directly to improve patency.
		Three-Dimensional Imaging System for Medical Diagnosis	1988 – 1991	about 300	The system for observation of real three dimensional images of organs and skeltons.	The synthesized multiplex holograms which shows a real three dimensional images of organs and skeltons is very useful for planning surgical operations.
		Laser Bone Scalpel	1989 – 1992	about 300	Laser bone scalpel which enables to cut bone sharply in any desired shape by controlling the incision depth during operation.	A safer and easier-to-use laser scalpel was developed.
	Welfare Apparatus	Module Type Motorized Wheelchair	1976 – 1978	about 200	Safe motorized wheelchair designed to suit the functions of the physically handicapped. Parts are moduled and standardized.	Many alternation of devices have been developed in this program such as a system operated by fingers, feet, jaw and etc. By moduling and standardization of the parts, semi order made manufacturing was achieved.
		Braille Uplicating System	1976 – 1978	about 200	Symple device for duplicating large quantity of braille books, etc.	This aids in popularizing braille nbooks.
		Gait Pattern Analyzer for the Handicapped	1976 – 1978	about 200	Device for measuring physical functions for effective training and evaluation of walking for the handicapped.	This device measures and analyzes the patients pattern and process of walking dynamically not only to treat the disabled, but also to design artificial legs and other devices.
		Multifunctional Bed for the Bedridden	1976 – 1978	about 100	Multifunctional bed on which a patient can relieve nature and take a bath while lying.	This multifunctional bed enables patients to relieve nature privately and easily while lying and also to bathe without moving from the bed.
		Middle Ear Implant	1978 – 1982	about 400	Implantable hearing aid.	This implantable hearing aid transmits sound directly to the inner ear. The material used for coating the device is of high biocompatibility.
		Guide Device for the Blind	1979 – 1983	about 400	The guide device detects obstacles by ultrasonic and photoelectric technology. The data is then be transmitted to the unser, mainly through hearing sense.	With this device, blind people are able to identify any obstacle in their path, and to protect themselves. They can walk while checking the safety of their steps.
		Vocal and Speech Training Device	1979 – 1983	about 300	Device for speech training without the need of trainers. The device is composed of a center-type training unit which is installed in language unit to be used by individuals at home.	This device is characterized, unlike conventional ones, by electric display of the conditions of the tongue and other vocal organs of the patient, and by visually grasping of the features of voices.
		Active Artificial Leg	1980 – 1985	about 400	Artificial leg which enables users to manipulate stairways and is suitable for the lifestyle of Japan.	This provides users with those actions sitting up straight and sitting cross-legged, stand up, crouch, walk on a level ground, etc.

		Project name	Period	Total exp.	Outline of Project	R&D Results
Medical and Welfare	Welfare Apparatus	Three-dimensional Working Chair	1981 - 1985	about 300	Wheelchair for physically handicapped workers. Smoothly movable forward, backward, left, right and up and down.	This provides its user with greater reach, access and movility.
		Book-reader for the Blind	1982 - 1988	about 600	This consists of an automatic page turning unit, an image scanning unit, a character recognition unit, a speech synthesizing unit and a speech recording unit.	An apparatus was developed which automatically reads Japnese books and that outputs the written data in synthetic speech format.
		Transfer Supporting System for the Handicapped	1983 - 1988	about 500	High performance equipment for bedridden patients to places like laboratory.	This allecviates the burden onthe helpers as well as help the disabled and patients to move easily at will, which may be come a great relief for the elderly in the long run.
		Automatically Body Temperature Adjuster	1984 - 1988	about 300	Automatic body temperature control device for the handicapped as wearable clothing.	This sytem is a wearable ensemble with heat medium circulation for cooling. High functional, light weight, convenient, pliable, small, low power consumption and negligible noise.
		System for Processing Prosthetic Sockets	1986 - 1989	about 200	System for processing rapidly high quality prosthetic sockets by CAD/CAM.	An automated system was developed for processing rapidly and inexpensively high quality prosthetic sockets for patinets by the application of ever-improving computer technology.
		Anti-Decubitus Mechanbical Mattress	1987 - 1990	about 200	A mattress for preventing decubitus ulcers of the bedridden and a bed for changing body position of the patient, thus reducing the labor of the attendent.	The mattress provide a system to control excessive contact-pressure in specific areas or a system to allow its activation. The bed maked it possible to reduce the labor of the attendant in changing body position of the patient.
		Health-Monitoring System for the Elderly	1990 - 1992	about 200	The "Health-Monitoring System for Elderly" is portable monitoring system for the elderly with sophisticated alarm system.	Small and private use monitoring system was developed. This system was composed of "vital sensor system" and "alarm System".

IMPLEMENTING ORGANIZATIONS

Project Name	Private Sector	Public Sector
Superconducting Materials and Devices:	International Superconductivity Technology Center EISIN KAIHATU Building 34-3, Shimbashi 5-chome, Minato-ku, Tokyo 105 TEL. 03-3431-4002 Research and Development Association for Future Electron Devices Hukide 2nd Building 1-21, Toranomon 4-chome, Minato-ku, Tokyo 105 TEL. 03-3583-8291	National Research Laboratory of Metrology National Institute of Materials and Chemical Research Government Industrial Research Institute, Osaka Government Industrial Research Institute, Nagoya Electrotechnical Laboratory
High-performance Materials for Severe Environments	R&D Institute of Metals and Composites for Future Industries 17-7, Toranomon 3-chome, Minlao-ku, Tokyo 105 TEL. 03-3459-6900	National Research Laboratory of Metrology Mechanical Engineering Laboratory Government Industrial Research Institute, Nagoya National Institute of Materials and Chemical Research Government Industrial Research Institute, Kyushu National Research Institute for Metals
Non-linear Photonics materials	Japan High Polymer Center 22-13, Yanagibashi 2-chome, Taito-ku, Tokyo 111 TEL. 03-3851-8860	National Institute of Materials and Chemical Research Government Industrial Research Institute, Osaka National Research Laboratory of Metrology Electrotechnical Laboratory
Advanced Chemical Processing Technology	Advanced Chemical Processing Technology Research Association FT Nihonbashi Hisamatsu-cho Building 10-6, Hisamatsu-cho, Nihonbashi, Chuo-ku, Tokyo 103 TEL. 03-3661-6561	Government Industrial Research Institute, Osaka Government Industrial Research Institute, Nagoya National Institute of Materials and Chemical Research National Research Laboratory of Metrology
Silicon-based Polymers	Japan High Polymer Center 22-13, Yanagibashi 2-chome, Taito-ku, Tokyo 111 TEL. 03-3851-5860	National Institute of Materials and Chemical Research Government Industrial Development Laboratory, Hokkaido
Marine Biotechnology (Fine Chemicals from Marine Organism)	Marine Biotechnology Institute 3F HONGO SEGAWA Building 35-10, Hongo 2-chome, Bunkyo-ku, Tokyo 113 TEL. 03 5684-6211	Government Industrial Research Institute, Osaka Government Industrial Research Institute, Shikoku Government Industrial Research Institute, Tohoku Government Industrial Research Institute, Chugoku National Institute of Bioscience and Human-Technology National Institute of Materials and Chemical Research
Molecular Assemblies for a Functional Protein	Research Association for Biotechnology SARUTA Bldg. 4-10, Akasaka 1-chome, Minato-ku, Tokyo 107 TEL. 03-3583-8291	National Research Laboratory of Metrology Electrotechnical Laboratory National Institute of Materials and Chemical Research National Institute of Bioscience and Human-Technology
Production and Utilization Technology of Complex Carbohydrates	Research Association for Biotechnology SARUTA Bldg. 4-10, Akasaka 1-chome, Minato-ku, Tokyo 107 TEL. 03-3583-8291	National Institute of Bioscience and Human-Technology
Bio-Electrical Devices	Research and Development Association for Future Electron Devices Hukide 2nd Building 1-21, Toranomon 4-chome, Minato-ku, Tokyo 105 TEL. 03-3434-3871	Electrotechnical Laboratory National Institute of Materials and Chemical Research
New Models for Software Architecture	Informa[illegible]-Technology Promotion Agency 6F Shuwa Shiba Koen 3-chome Building 1-38, Shiba Koen 3-chome, Minato-ku, Tokyo 105 TEL. 03-3437-2301	Electrotechnical Laboratory Mechanical Engineering Laboratory
Quantum Functional Devices	Research and Development Association for Future Electron Devices Hukide 2nd Building 1-21, Toranomon 4-chome, Minato-ku, Tokyo 105 TEL. 03-3434-3871	Electrotechnical Laboratory
Ultimate Municipation of Atoms orMolecules	Angstrom Technology Partnership 8F Ryukakusan Building 5-12, Higashi Kanda 2-chome, Chiyoda-ku, Tokyo 101 TEL. 03-5821-3777	National Institute for Advanced Interdisciplinary Research
Advanced Material Processing and Machinery System	Advanced Material-Processing and Machining Technology Research Association 10F Sumitomo Seimei Shin-Osaka Building South Wing 5-15, Nishi-Nakajima 5-chome, Yodogawa-ku, Osaka 532 TEL. 06-390-7021	National Research Laboratory of Metrology Mechanical Engineering Laboratory Electrotechnical Laboratory National Institute of Materials and Chemical Research Government Industrial Research Institute, Osaka Government Industrial Research Institute, Shikoku
Super/hyper-sonic Transport Propulsion System	Engineering Research Association for Super/Hyper-Sonic Transport Propulsion System 2F Koishikawa IS Building 2-8, Kohinata 4-chome, Bunkyo-ku, Tokyo 112 TEL. 03-5684-5180	National Aerospace Laboratory National Research Laboratory of Metrology Mechanical Engineering Laboratory Government Industrial Research Institute, Osaka
Micromachine Technology	Micromachine Center 3F SANKO Building 12-16, Mita 3-chome, Minato-ku, Tokyo 108 TEL. 03-5443-2971	National Research Laboratory of Metrology Mechanical Engineering Laboratory Electrotechnical Laboratory
Manganese Nodule Mining System	Technology Research Association of Ocean Mineral Resources Mining System 6F New Tokyo Building 11-13, Ginza 5-chome, Chuo-ku, Tokyo 104 TEL. 03-3542-6091	National Institute for Resources and Environment
Underground Space Development Technology	Engineering Advancement Association Toranomon Takagi Building 7-2, Nishi-Shimbashi 1-chome, Minato-ku, Tokyo 105 TEL. 03-3502-3671	National Institute for Resources and Environment Geological Survey of Japan Mechanical Engineering Laboratory
Human Sensory Measurement Application Technology	Research Institute of Human Engineering for Quality Life Nansei Building 4-13, Awajicho 4-chome, Chuo-ku, Osaka-shi, 541 TEL. 06-222-2901	National Research Laboratory of Metrology Mechanical Engineering Laboratory National Institute of Bioscience and Human-Technology National Institute of Materials and Chemical Research Electrotechnical Laboratory Government Industrial Research Institute, Osaka
Health, Medical and Welfare	Technology Research Association of Medical and Welfare Apparatus 5-8, Shibakoen 3-chome, Minato-ku, Tokyo 105 TEL. 03-3459-9584	National Institute of Bioscience and Human-Technology Mechanical Engineering Laboratory Electrochemical Laboratory Government Industrial Research Institute, Osaka

Note 1: The private sector research was commissioned by New Energy and Industrial Technology Development Organization.
Note 2: University support of research was subcontracted by the private sector.

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